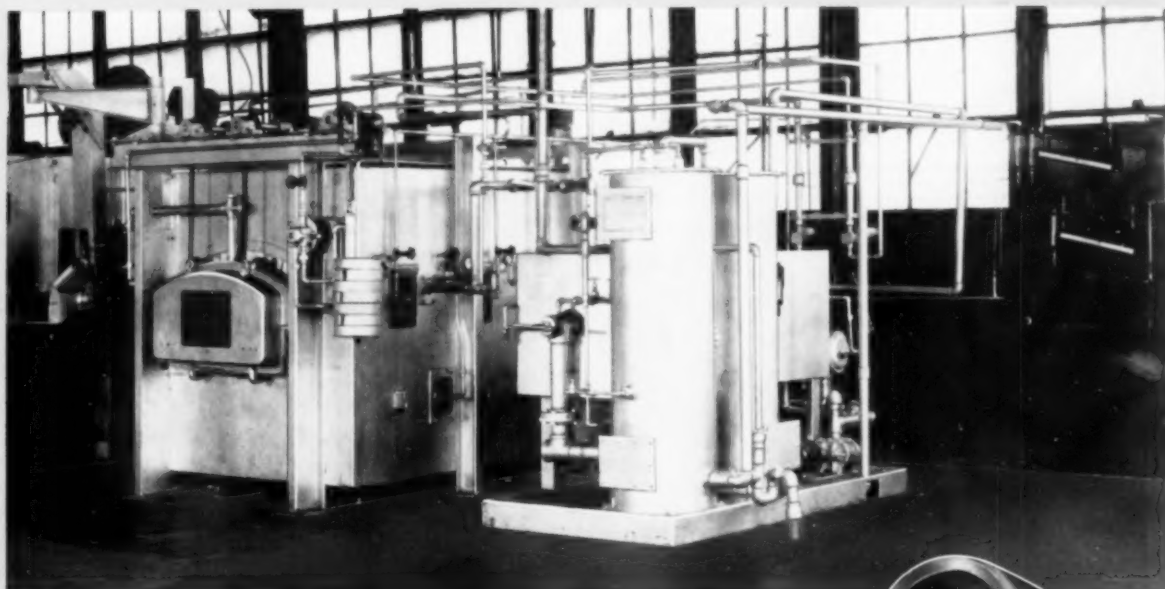
MAY 1935

Metal Progress

THE AMERICAN SOCIETY FOR METALS

Now —GAS CARBURIZING IN HORIZONTAL BATCH UNITS



BY THE EUTECTROL Process

Illustrated above is one of several horizontal installations of the batch type gas carburizer in use.

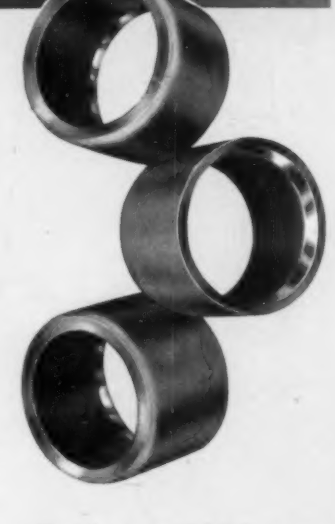
This horizontal unit is of special interest to metallurgists and heat treating men, because it produces uniform carburizing and allows accurate direct quenching.

This development embodies the same fundamentals as those incorporated in the well known SC *Eutectrol* Continuous Gas Carburizers, which were originally developed (and are built only) by Surface Combustion Corporation.

This batch-type gas carburizer, like the Eutectrol, has many outstanding advantages over the older carburizing methods. It eliminates the use of packing and dirty compounds; it eliminates boxes and the necessity for heating a large amount of excess material — thereby saving fuel. It saves labor and floor space.

Uniform quality production is easily maintained. Rejects are negligible. Uniform depth and character of case are obtained.

And savings over the older methods are estimated at 30 to 60 per cent!



Bearing races and cones of 4615 SAE steel are carburized. Case depth .035 — Rockwell 62-66 — Production rate 900 pounds per 12 hours — Carburizing gas prepared in Surface Combustion Gas Preparation Unit — Write for additional data.

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METAL PROGRESS

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Ernest E. Thum, Editor

SURFACE CRACKING

in forged shaft

& axle journals

by H. H. Ashdown
Consulting Metallurgist

IN MANY YEARS OF EXPERIENCE WITH LEADING steel works and manufacturing companies both in England and America the author has examined a number of heavy axles and shafts whose journals had developed serious surface cracks. This type of failure is well known to engineers in charge of the maintenance of rolling stock, both for steam railroads and street car lines. Such cracks have also appeared on journals of armature shafts and reversing engine cranks. Two distinct types of cracks are met, (*a*) the straight longitudinal cracks and (*b*) those resembling the characteristic grinding cracks.

The service conditions of axles of a modern railroad car or street car are similar to the conditions of heavy surface grinding or grinding with a loaded wheel. They are under considerable load, run at fairly high peripheral speed, and are subject to rapid decelleration by heavy brake action which induces high skin tension. Consequently the cracks in an axle journal and a surface-ground tool should be similar, as indeed they frequently are. Note the first pair of photographs (page 30). At left is a photograph of a portion of an axle journal, while at right is a tool steel plate heavily ground, intentionally, to produce shatter cracks so as to be used for an illustration for this article.

It is believed that shatter cracks of this sort are due essentially to the same causes that produce the longitudinal cracks noted as (*a*) above. The author lately made an investigation of two such failures for the Westinghouse Electric & Mfg. Co., and this will be described in detail since they are characteristic of many other similar failures examined by me. These forgings were made from alloy steel of the following composition: Carbon 0.33%, silicon 0.21, manganese 0.67, nickel 1.27, chromium 0.56, sulphur 0.037, and phosphorus 0.028%.

The 4-in. journal selected for detailed examination was separated from the axle, a 1-in. disk cut to study the penetration of the cracks, and the remaining portion split lengthwise down its axis. One half was cut into test pieces; physical tests follow:

Elastic limit	76,000 psi.
Yield point	86,000
Ultimate strength	112,000
Elongation	24.5% in 2 in.
Reduction of area	62.7%
Izod impacts	63, 65, 64 ft-lb.

The other half was polished on its longitudinal axial section and first treated with 5% nital; nothing abnormal was found. Microstructure shown on page 31, typical of the structure throughout, indicates good heat treatment, and leaves room for little comment.

Next the entire lump was pickled for 15 min. in boiling hydrochloric acid (50% solution). The result of this etch is illustrated in the pair of full size views on pages 32 and 33. One illustrates the internal structure of the piece; it could hardly be improved upon. The other shows the condition of the cylindrical bearing surface. In addi-

tion to bringing the major cracks into relief (and these were matched by a similar system of cracks located about 180° opposite), this treatment has also exposed a number of incipient cracks, several of which could be faintly detected by a strong hand glass. These minor cracks in continued service would eventually have developed into cracks the full length of the journal. We have seen several exceptional examples which had many full length, deep cracks spaced almost equally around the periphery of the journal.

Depth penetration of the very narrow crack was subsequently photographed in the cross-section, being approximately ½ in. deep. Another section cut midway between the longitudinal axis and the outside disclosed no abnormal segregation or inclusions. The piece can therefore be considered as being made of a clean, commercial steel.

In reviewing some of the suggested causes of these failures, first consider defective steel. Forgings for the services outlined are made from metal of best forging quality. The ingots from which they are forged are, or should be, cast under the best conditions controlled with a view of obtaining a surface free from gas cavities and fissures, and the segregates suppressed.

This would appear to be an opportune occasion to suggest that all axles (and other types of forgings as well) should be forged near to the finished journal or bearing size, to retain as much of the outer portion of the original ingot on the finished surface as possible. No commercial steel has yet been made, or is likely to be made, free from internal inclusions or segregation, and the deeper a forging is machined the greater are the possibilities of disclosing such defects.

Similarity of Surface Crackings on Car Axle Journal (Left) to Shatter Cracks Intentionally Produced by Heavy Grinding a Hardened Tool Steel Flat (Actual Size)

We have inspected satisfactory rolled bars supplied for axles, and after the journals have been machined minor defects have caused rejection. It is not uncommon for bar stock to be reduced in diameter as much as 50% in machining and for complaints then to be made about "surface" inclusions. It must be an accepted fact that the central portion of any ingot (and bar stock corresponding) will be lacking in homogeneity. Let such metal stay at the center of an axle, where it can do the least harm, for there it carries only the most moderate stresses.

At any rate, the photographs herewith showed that the metal was very good, yet the axle failed after comparatively short service.

It also has been suggested that the forging flow lines are responsible for these longitudinal cracks. This thought, however, is not consistent with the shatter cracks frequently found on the same type of forging, at right angles to the direction of the flow lines. Still it must be admitted that once surface cracks have been produced, the directional flow assists in spreading them.

Grinding also has been suggested as the cause of these failures. Grinding will produce them, but not if this operation is carefully controlled. We have seen axles of both straight carbon and alloy steels finished and then hand polished on the lathe, yet in service they have developed these same defects.

From the number of examples of this type of failure examined over a period of many years, we cannot agree that these cracks usually originate from the causes already cited. It is true that any minor longitudinal defects on the journal surface are initial starting points for the promotion of these cracks should such parts in service be subjected to high surface stresses. It is equally true that steels containing small unwelded blowholes below the surface offer a ready path for these cracks once they have been initiated on the surface. But due to the rigid examination made on finished surfaces of these important machine parts it is doubtful if any pass into service even with minute marks; if any are

Etched Section Normal to Surface Reveals Crack Penetrating About ½ In. Deep Into Sound Metal. Width of crack at surface has been enlarged by pickling solution. Magnification 15 times

approved with the smallest doubt, a careful record is kept of them.

It has been stated that axles made from alloy steels are especially prone to these surface cracks. Although we have seen a number of them, the ratio has not been sufficiently convincing to us to support that contention — in fact rather the opposite. If it is admitted that an analogy exists between grinding cracks and longitudinal cracks in axles under service conditions, it could be maintained that carbon steels are more susceptible than alloy steels.

The fact, however, must not be lost sight of that since the development of alloy steels (particularly in more recent years) advantage has been taken of their higher physical properties. In some instances the cross-sections have been reduced; in others, loads have been greatly increased; in still others the parts are used in more exacting service conditions; in general the speeds are also higher, resulting in heavier brake action and greater surface stress, which has a deleterious action, as will be pointed out shortly.

Occur in Sound Metal

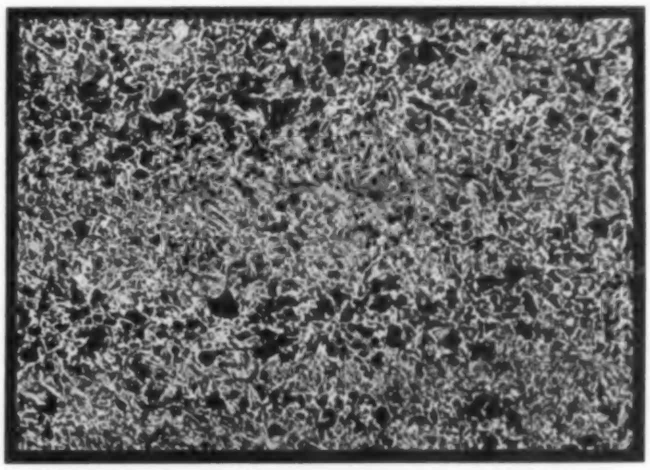
The general conclusion may therefore be drawn that from a viewpoint of satisfactory physical properties and structural condition, the designer has the assurance of the testing engineer or plant metallurgist that the material has conformed to the specified physical properties and is also in a satisfactory structural condition.

The service life of axles, therefore, starts off with a material of unquestionable high quality, and it would appear that this problem of cracking must develop from causes arising under service conditions.

It is the belief of the present writer that longitudinal cracks on journals are to be found on the units which run rather steadily, that is to say, where the axle or shaft is occasionally subjected to heavy loading such as the heavy duty occasionally thrown on to an armature shaft resulting from load fluctuations, the stress reversals on reciprocating engine crank-shafts, or the sudden loading on a rolling mill engine at the moment the rolls pinch a heavy billet. The longitudinal type of crack was also more common years ago on both railroad and street car axles when traffic was running at slower speeds and under lighter loads.

The skin stresses on these revolving parts under their service conditions are not unlike the conditions when a slightly increased pressure is used between wheel and work during the surface grinding of a hardened tool.

Analogies sometimes assist. We know that practically all metals and alloys will take a high degree of luster by polishing, and that this highly reflective surface is the result of flow of a thin



Microstructure (75X) of Clean and Sound Nickel-Chromium Axle That Cracked on the Journals. This and the other photos were prepared by Miss M. Ferguson, metallographist, at Westinghouse Research Laboratory

film at the surface. A practical illustration of the surface flow of metal in the plastic condition may any day be seen in plate mills, when the two surfaces flow over the center, and the ends of the plate after the last pass give the impression that the central portion has receded considerably.

Again, if we take a piece of thick sheet rubber, lay it on a flat surface and lightly pass a roller over the surface, we see a slight hump immediately in front of the advancing roller.

If we now consider the action of surface grinding (at the same time bearing in mind the foregoing examples) we may better appreciate what is taking place. The grinding wheel is running in the opposite direction to the transverse of the object being ground, and any pressure between the contacting faces has the effect of rippling up the skin of the metal. This, in hard materials, induces surface stresses far in excess of its elastic limit and results in rupture. Although these are only film cracks, these cracks soon deepen into the material if not quickly removed, due to the metal under the surface having also been highly stressed, either by the grinding or the hardening processes.

A somewhat similar occurrence may sometimes be seen when cold shearing small billets or plates of alloy steels or medium high carbon steels. Due to the exceedingly high tension stress introduced into the sheared surface, cracks the full width of the face will appear, and if these are not quickly removed or the stresses relieved by heat, they will deepen into the material.

This skin flow or skin tension of metals is a factor of great importance, as there are many service conditions (particularly in roller bearings, ball bearings, and gearing) where it is apt to arise. Seizing of bearings and rubbing surfaces on gate valves are other examples given to confirm the fact of film flow and the results which may be anticipated in the absence of ample lubrication. In most of the examples cited (polishing, grinding, and shearing) it should be observed that considerable surface heat is also generated, and this heat is rapidly dissipated into the colder mass, so that a "self-quenching" action induces high surface hardness on steels.

Returning now to our axle problem: If a journal is examined after a short period of service, and particularly if lubrication has been limited, or the bearing has run dry even momentarily, the surface will be highly polished. This, therefore, is evidence of both high skin tempera-

Photos, Approximately Full Size, of Deeply Etched Axle. Rectangular section through center shows forging flow lines but excellent homogeneity and cleanliness. Cylindrical wearing surface is more resistant to acid, but longitudinal cracks, long and short, are eaten into by the solution

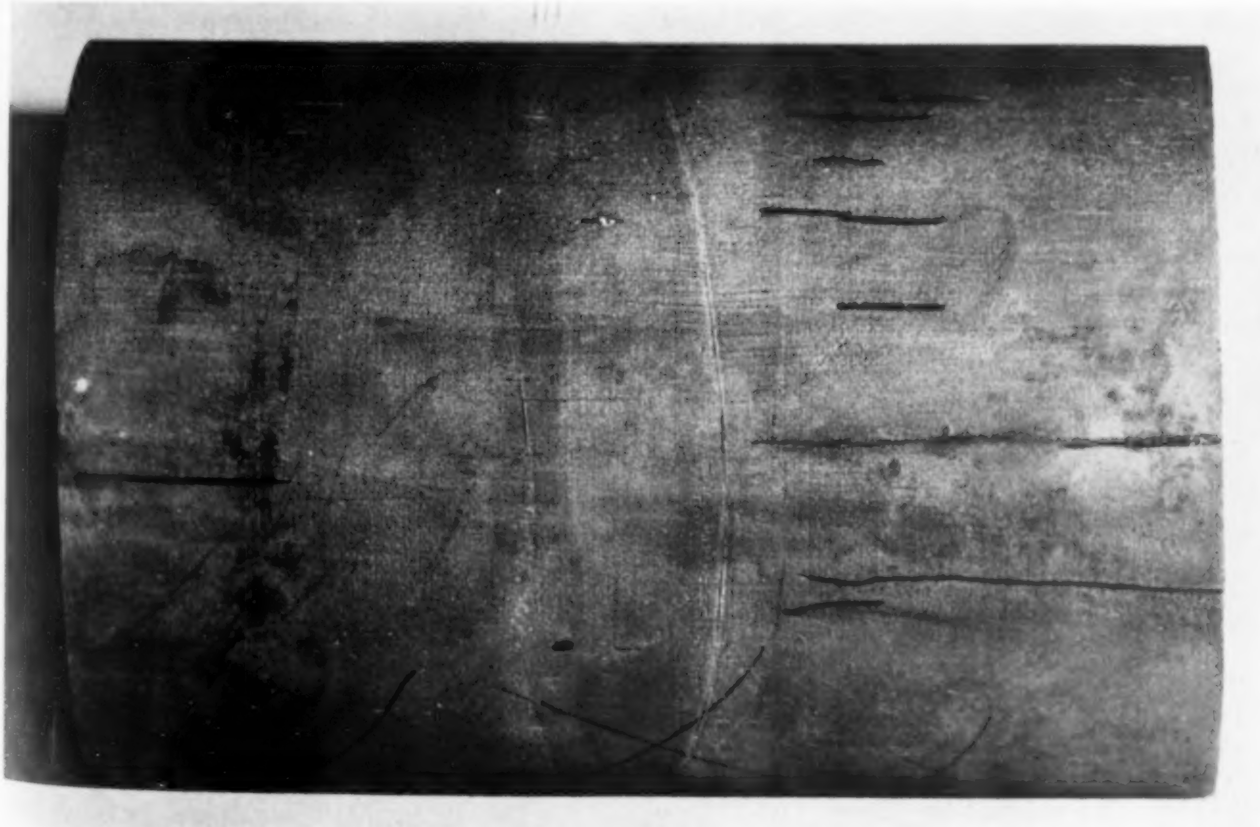
ture and of film flow. This film flow is in a regular direction and usually for the full width of the journal. While the axle is running steadily at a high speed, this tendency of surface flow is in one definite direction, but when an increased load is suddenly thrown onto the unit (or sudden braking is applied) the effect is to sharply arrest the direction of rotation and to arrest also the film flow. This introduces exceedingly high tension stresses on the journal surface, often resulting in rupture of the skin. Once this happens an aggravated condition may arise, as the ruptured axle surface may tend to score the bearing, quickly producing hot boxes.

Stresses from Brake Action

Railroad rolling stock and street car axles receive severe treatment in this respect, since in addition to running at fairly high peripheral speeds and carrying the load direct they are subject to continual and heavy brake action. Under these conditions the journals become warm, tighten in the bearings, and cause metal-to-metal contact, simulating the conditions of heavy grinding. Shatter cracks may then be anticipated. The pernicious habit, sometimes unavoidable, of cooling hot bearings with water has either the effect of developing these cracks or rapidly deepening any cracks already formed. This again has its counterpart in grinding.

What in reality is taking place is a severe plastic deformation of the steel. Cracks form in certain areas and are propagated by continual repetition of the stresses responsible, stresses which are above the endurance limit of the steel.

Thus, surface cracking appears to have little relation to physical and tensile properties as ordinarily determined. As already indicated by experience in grinding, the harder materials offer greater resistance to surface flow, but the surface is more easily ruptured. Provided the axles on which these defects occur have received a good heat treatment and have a well-refined structure, and provided they are efficiently lubricated, they may still give a considerable service life as it takes a period of time for these cracks to travel through the fine grain and attain much depth. This discussion indicates that service conditions should be carefully watched — especially the lubrication. Ingots should be cast with expert attention to the skin effect, and from them should be forged slightly oversize axles, machined lightly to surfaces free from inclusions, "ghosts," and checks. Something can also be done in limiting the load fluctuations on the axle, or at least preventing these fluctuations from occurring at high acceleration.



STRUCTURAL ALUMINUM

fabrication and utility

by R. L. Templin
Chief Engineer of Tests
Aluminum Co. of America

A 175-Ft. Boom and 6-Yd. Bucket of Mud Would Topple the Biggest Excavator; Hence It Is Built of Structural Aluminum, When the Machine Then Becomes More Stable Than With a 150-Ft. Steel Boom

A SIGN POSTED ON THE BROOKLYN BRIDGE reads: "Traffic restricted to passenger autos (except buses), newspaper delivery and U.S. mail trucks. Horse-drawn vehicles allowed except from 4:30 to 6:30 p.m. week days. Speed limit 15 miles per hour."

Two conditions have made such restrictions necessary: First, natural deterioration with age, and second, the profound and quite unpredictable changes that have affected the character of traffic since the bridge was built. Continuation of these restrictions is at best a temporary expedient. A permanent solution which immediately suggests itself is to build a new bridge, but another plan has been proposed which will accomplish the same result at a fraction of the cost. This plan provides an aluminum floor system for the present one of iron and steel, at a cost of $8,250,000 instead of the $40,000,000 required for an entirely new structure.

Readers of METAL PROGRESS have seen many articles about the strong aluminum alloys, so that it is only necessary to refresh their memory with a few facts contained in the table on top page 37. They may not be so familiar with the fact that sheets, plates, rods, bars, I-beams, H-beams, channels, angles, tees, and zees are available in a wide variety of sizes and weights, as well as more complicated extruded sections, suitable for architectural trim or car construction. No designer need be handicapped by lack of suitable shapes.

Shop Fabrication

In general, shop equipment and practices suitable for fabricating structural steel are used for these structural aluminum alloys, except that they, being heat treated, cannot be welded or hot formed except when properly reheat treated or when the loss in mechanical properties can be compensated for in the design. The torch cannot be used to cut aluminum, but the metal can be punched, sawed, sheared, drilled and riveted on the same machines used for steel. For best results, it is advisable to give cutting edges more top and side rake, but this can be taken care of when the tools are sharpened.

Layout work on aluminum is easy because of the bright, smooth surface which can be readily marked and center-punched.

The ease with which aluminum may be sawed and sheared compensates in some degree for the fact that it cannot be cut with a torch. Either a bandsaw or circular saw may be used; for heavy sawing, the teeth should be swaged to provide clearance and prevent overheating. Lubricants may consist of soluble compounds, reclaimed lubricating oil, kerosene, or a mixture of kerosene and lard oil. Friction saws produce a very rough cut, and should be avoided.

Rivet holes may be punched, sub-punched and reamed, or drilled. Single, automatic and gang punches have all been used successfully in the fabricating shop; the type of equipment depends on how much work is to be done and on the shape of the piece being punched. In punching a row of holes in a long structural member, little warping and practically no change of length are noted, even on fairly low edge distances. This is explained by the combination of low elastic modulus and high yield strength of the aluminum alloys; the permanent distortion is confined to a small area. Drilling and reaming proceed about twice as fast in aluminum as in steel, since both rotational and feed speeds may be increased.

Bending may be done cold if the radii are not too short. Edges should be smooth and free from burrs so that cracks have no place to start. For more severe operations on important members made of 17S-T, forming must be done at the heat treating temperature under pyrometric control, and quenching must follow without delay. Forming of moderate severity on aluminum alloy 27S-T can be accomplished readily by heating the members locally to between 300 and 400° F., the aging temperature.

Most of the larger girders and trusses are fabricated with steel rivets driven hot in the usual manner. A number of traveling cranes have been successfully riveted with aluminum alloy rivets, but their use in diameters upwards of ½ in. will usually increase the cost per pound of weight saved. Hence where special considerations do not dictate aluminum rivets of the larger sizes, steel rivets are generally employed. Steel rivets, of course, require painting, but this introduces no new problem, since paint protection is recommended for most aluminum structures, regardless of rivets.

Design Considerations

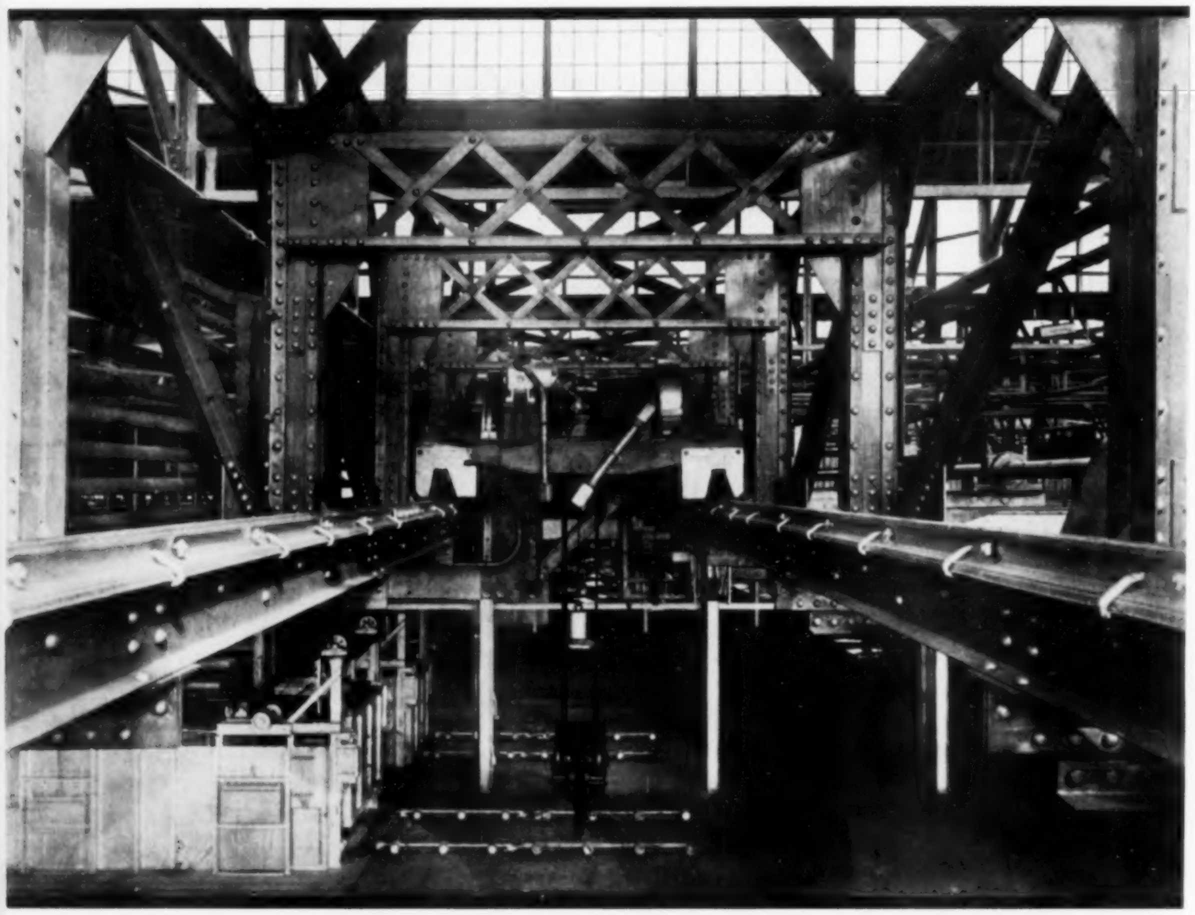
In designing it is necessary to consider all of the properties of the material in order to obtain the most efficient structure. Most important of these are strength, weight, elastic modulus, coefficient of thermal expansion, initial cost, and cost of erection. Section-for-section substitution of aluminum for steel is frequently very poor

engineering practice, for the metals differ from each other in all the above characteristics.

An example will illustrate: It is often desirable to limit deflection in a beam to a fixed value (say, to avoid cracking of plaster on ceilings underneath). A 17S-T beam would be just as strong to resist a load in bending as a structural steel beam of the same dimensions, since the unit tensile strength is the same. But, because the modulus of elasticity of aluminum and its alloys is one-third that of steel, it is necessary to deepen the aluminum beam or increase other dimensions to secure comparable rigidity or stiffness. The table at the foot of the opposite page gives comparisons.

Other differences between aluminum and steel designs result from the relations of the initial material costs and the costs of fabrication. The design that is easier to construct is usually the more economical in steel, even though it may be heavier. In aluminum, the more economical structure is usually the one that uses the least material, since the cost of the metal is high in comparison with the cost of fabrication and erection. For these reasons, the tendency is to use trussed members of aluminum instead of plate girders of steel.

An aluminum structure will frequently cost more initially than a steel structure intended for the same purpose; its use is justified when it performs the same function as if built of heavier materials, yet at a sufficient saving to recover its higher initial cost within a reasonable period of time, or when its light weight allows a sufficient saving of material in the supporting structure.



An Aluminum Alloy Shop Crane. An aluminum crane weighs about half as much as a steel crane of the same capacity and hence can sometimes be installed in a building which is not originally designed for a crane without the necessity of replacing foundations and columns

Take, for instance, the 175-ft. dragline boom used in building levees on the Mississippi River, and photographed on page 34. Since a pound of weight saved at the end of a boom is equivalent in overturning moment to two pounds saved at its center, the outer 140 ft. of this boom was made of aluminum and the remaining 35 ft. of steel. The total weight of boom, accessories and loaded 6-yd. bucket is about 61,000 lb., and the overturning moment at maximum reach is 8,650,000 ft-lb. Compare this with a 150-ft. steel boom which weighs with the same accessories about 84,000 lb., and involves an over-turning moment of 9,500,000 ft-lb.

The dragline excavator equipped with a composite aluminum-steel boom can therefore handle the same load at a 14% greater radius with greater stability than one equipped with a 150-ft. all-steel boom. The greater reach reduces the amount of earth rehandling and the number of times the whole machine must move ahead to handle a given yardage. But this is not all, for dynamics as well as statics must be considered in determining how fast the machine can work. It is found that the inertia of the swinging aluminum boom is 8.6% greater than the steel boom

when the bucket is loaded and 4.1% less when empty. The net increase in inertia is negligible in its effect on working speed, in comparison with the saving in idle (moving) time gained by the greater working radius. It has been found that the working capacity on the job is increased anywhere from 10 to 25%, and herein lies the economic justification for a higher priced but lighter weight structural material in a boom.

Typical Mechanical Properties of Structural Aluminum Alloys

Modulus of elasticity: 10,000,000 psi.
Coefficient of thermal expansion: 0.000013 per °F.

Alloy	Principal Use	Weight per Cu.Ft.	Tensile Strength	Yield Strength	Elongation in 2 In.	Shear Strength
27S-T	Strength Members, Painted	174 lb.	61,000 psi.	49,000 psi.	10%	37,000 psi.
17S-T		174	58,000	35,000	20	35,000
53S-T	Corrosion Resistant Members, Unprotected	168	35,000	30,000	12	26,000
*52S-T		166	41,000	35,000	7	24,000

* Not heat-treated; strength derived from cold working

Savings in Static Structures

An important use for aluminum is to minimize dead load on an existing supporting structure. Aluminum cranes can often be installed in shop buildings not designed for cranes fabricated from the more conventional and heavier materials.

For instance, a plan for remodeling an incinerator in New York City included the installation of four overhead cranes of 33 to 36-ft. span in a reconstructed building. By using aluminum cranes, the original foundations were sufficient, whereas four steel cranes of the same span and capacity would have required a new and stronger foundation. The weights involved were as follows:

Aluminum crane fully equipped	13,700 lb.
2-cu.yd. aluminum grab bucket	2,500 lb.
2 cu. yd. of load (refuse)	1,500 lb.
Total	17,700 lb.
Steel crane fully equipped	21,700 lb.
2-cu.yd. steel grab bucket	4,000 lb.
2 cu. yd. of load	1,500 lb.
	27,200 lb.

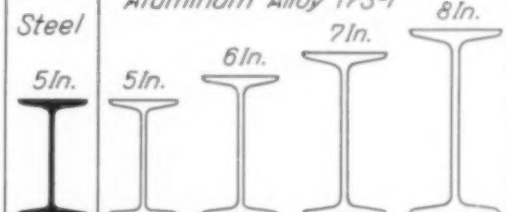
A similar economic principle is applied on a grand scale to the rebuilding of an existing bridge. By replacing a portion of it with structural aluminum, the dead load on the original supporting structure may be reduced so as to increase the permissible loadings on the same number of traffic lanes, or the dead load may be held constant for an increased number of lanes. Either of these schemes may provide a highly economical alternative to building a new bridge. Under certain conditions both lighter dead weight and a larger number of lanes may be obtained. An example of the first case, in which the number of lanes was considered sufficient, but, under existing conditions, traffic had to be limited to avoid excessive loads on the supporting structure, is to be found in the Smithfield Street Bridge at Pittsburgh.

This bridge was designed by Gustav Lindenthal and erected in 1882. It consists of two identical 360-ft. spans of three Pauli or double-elliptical trusses each, carrying a roadway suspended below the trusses by pin-connected hangers. The upstream roadway carries a double-track street railway; the other is for vehicular traffic. The original floor system consisted of wrought iron plate girder floor beams and longitudinal stringers supporting an 11-in. laminated timber floor, surfaced with steel traffic plates. Sidewalks, bracketed out on both sides of the bridge, were floored with 2-in. plank.

Frequent repairs and a constant fire hazard indicated the need of replacing the floor. At the same time, it was realized that if some dead load could be removed from the bridge structure, which was fundamentally sound, its useful life could be extended, postponing the construction of a new bridge.

Attention being directed to structural aluminum, a floor system was designed which, according to best judgment, would add some 25

Comparison of Standard I-Beams in 17S-T and Structural Steel



	Steel 5 In.	Aluminum Alloy 17S-T 5 In.	6 In.	7 In.	8 In.
Weight	100	35	44	54	65
Strength	100	100	150	214	294
Stiffness	100	35	62	103	162

Reconstruction View of the Smithfield Street Bridge Showing an Aluminum Floor Beam Being Hoisted Into Place

years to the useful life of the bridge. This represents about the limit of safe predictions concerning traffic. At the same time, the fire hazard and the constant necessity for repair are eliminated.

The general design of the present floor beams and stringers is very similar to that of corresponding steel members, except that more attention was given to saving material. The floor beams, 39 in. deep in the street car roadway and 42 in. deep under the crown of the vehicle roadway, were spliced near the center truss to facilitate erection without interrupting street car service; temporary car tracks were laid on the vehicle roadway during the replacement of the railway floor system. There are four load-carrying stringers on the railway side, one under each rail, and two side stringers which act as wind chords. All these stringers are 36 in. deep. The track stringers are reduced in depth toward the ends in order to save weight.

The deck panels on the highway side consist of a 7/16-in. aluminum tread plate supported on 7-in. channel joists spaced 8 in. on centers. The joists rest on top the intermediate and main floor beams. A transverse 8-in. distributor channel is rigidly attached across the middle of the joists to give the whole panel the action of a deep slab. Last, a 1½-in. asphalt surfacing was laid on the tread plates, whose raised pattern acted as an anchorage to prevent creeping. These deck panels weigh complete only 30 lb. per sq.ft. and are durable and fireproof.

The sidewalks are carried by aluminum framing and consist of a ¼-in. aluminum plate surfaced with ½ in. of asphalt and reinforced underneath with 2x2-in. angles. The top of the sidewalk handrail is of 5x3-in. oval tubing, the bottom rail a 4-in. channel, and the balusters are 1½-in. tubing expanded into the top and bottom rails by a tool resembling a boiler tube expander.

All load-carrying members of the floor system were of alloy 27S-T, which has a yield strength equal to that of silicon steel. The handrail tubing is of 4S-H, not heat treated, and the rolled shapes in the handrail are of 53S-T, both alloys being exceptionally resistant to corrosion and requiring no painting. The floor members are all painted with a primer (iron oxide plus zinc chromate) covered with two field coats of aluminum paint.

The design stress used for the structural members was 15,000 psi. and the roadway was designed for "H-20" loading at any point. Whereas the combined panel load on three trusses of the old inadequate floor system was 119,153 lb., the combined panel load of the new system is

only 61,350 lb., saving 57,803 lb. in dead load for each panel. There being 26 panels, the total reduction in weight was 751.4 tons, or a little over one ton per lineal foot of bridge. The highway floor can now carry 20-ton, 4-wheel trucks, whereas loads had previously been limited to 13-ton trucks. On the street railway side, a clear headway of 50 ft. was formerly required between cars which weigh about 70,000 lb. each. This restriction is now removed; moreover, the bridge is safe for occasional 90,000-lb. cars.

The total contract price of this reconstruction was $276,436, of which $192,000 was for fabricated structural aluminum. This cost was covered by a $300,000 serial, 10-year bond issue, at 4½% interest, making the ultimate cost $370,000. This may be considered to be the cost of postponing for 25 years the building of a new bridge costing about $1,250,000. If that cost were covered by similar bonds maturing in 25 years, it would total $1,935,000. Reconstruction with structural aluminum has therefore saved the taxpayer $1,564,875 — actually more than the first cost of a new bridge!

Weight saving on new bridges of long span is worthy of consideration. It may be surprising to know that the 1470-ft. span on the Manhattan Bridge weighs 24,000 lb. per lineal ft. and can carry a live load of only 11,000 lb. per lineal ft. The new, magnificent George Washington Bridge across the Hudson River, a 3500-ft. span representing the best ideas in steel construction, has a dead load of 40,000 lb. per lineal ft. to carry a live load of 8000 lb. per lineal ft. By employing structural aluminum in the portion of a long span bridge that supports only its own dead load and live load, material may be saved progressively in all parts of the supporting structure down to the anchorages. A careful summation of the costs involved will reveal to what extent it should be used in a bridge for the greatest economy.

But of more interest at this time than a hypothetical new bridge is the plan proposed by Dr. D. B. Steinman, the internationally known bridge engineer, for reconstructing the famous 52-year old Brooklyn Bridge, known to the layman as the archetype of all suspension bridges. In reality, the Brooklyn Bridge is structurally obsolete in many respects and is, furthermore, inadequate to carry the traffic. Hence the sign noted at the outset of this article.

Rather than construct a new bridge to supplement or supplant the present structure, Steinman proposes to replace the suspended deck carrying six lanes of light traffic with a twelve-lane double deck system made of alloy 27S-T. As a result of its high strength-weight factor, the dead load on the cables will not be increased over its present value, 8400 lb. per lineal ft. A unit stress of 22,000 psi. is used as a basis for this design.

Since rapid transit traffic over the bridge, unlike vehicular traffic, has declined for the past 20 years, it will be rerouted through the subway. Street railway traffic has even more sharply declined and will be eliminated altogether. Thus the bridge will provide twelve lanes, 10 ft. clear, for vehicular traffic between lower Manhattan and the Borough Hall district of Brooklyn.

To Modernize the Brooklyn Bridge

An essential principle of the plan is, of course, to eliminate indeterminate trusses and obsolete features of the present structure. For example, the present double tension, quadruple intersection, stiffening truss with pin joints will be replaced with a simple riveted Warren stiffening truss, and the complicated system of diagonal stays and vertical suspenders will be replaced with a simple system of vertical suspenders, as is the practice in all modern suspension bridges. The roadway will be of the "battle deck" type, similar to that used in the Smithfield Street Bridge, but designed for "H-25" rather than "H-20" loading, since this bridge is a main artery of traffic.

The cables, towers and anchorages have suffered far less from the effects of time than have the suspended parts of the structure. Consequently, they are fully adequate to take care of the expected increase in live load which will follow reconstruction of the bridge. Under the extreme theoretical conditions of loading, the live load of 3444 lb. per lineal ft. plus the 8400 lb. per lineal ft. dead load will produce a maximum unit stress in the main cables of 57,500 psi. — well below the 120,000 psi. elastic limit of the cold drawn bridge wire. The safety of the anchorages will also be quite adequate.

The cost of the project, including new approaches, removal of present structure, erection of new structure, engineering and contingencies, has been estimated at $8,250,000. A new bridge designed to accommodate merely the surplus traffic which cannot use the present bridge would cost over $40,000,000. The use of structural aluminum, because it makes use of existing parts of the bridge that would be the most expensive to rebuild, therefore would save $31,750,000.

A MAN OF METALS

Albert L. Marsh

He made alloys of nickel and chromium (as pure as he could get in 1903) into thermocouple elements, and in studying their electrical characteristics he discovered their high resistivity and durability at elevated temperatures and thus found the material which is responsible for our multitude of devices heated by electricity

"MIGHTY MEN OF METALS" WAS THE SUGgested name of a department contained in the first prospectus of METAL PROGRESS. Such a department has its possibilities, but when attempting to work them out one finds that most of the "mighty men" who come to mind are men who have already had more than ample publicity and who are mighty in the realm of metals only incidentally to business or finance. Where is that outstanding man, remarkable for achievements in metallurgy, but modest in his public relations?

One such is to be found in a simply furnished office on the second floor of a manufacturing company in Detroit; an office door so constantly open that the words "A. L. Marsh, President and General Manager," are concealed. His real title is friend and advisor to his associates — whether in office, research laboratory, mill, or on the road. He is there because after 30 years he still believes there is much yet to learn about the nickel-chromium resistance alloys and thermocouple wires. He is there surrounded by men of proven worth, whose ability to solve the problems of yesterday convinces him that they will do the same today and tomorrow.

For it was in 1903 that Albert L. Marsh, a young bachelor of science in engineering chemistry from the University of Illinois, then working for the Chicago Storage Battery Co., became exasperated with the short life and insensitivity of thermocouples and determined to do something about it. He had an idea that the nickel-copper and nickel-iron wires furnished him could be improved by adding chromium, then a rare and untried metal, and began experimenting on his own. His first melts were made in a "cupola" — a short brick shaft built on a blacksmith's forge, wherein the alloys were melted by coke in a Battersea crucible. His new nickel-chromium alloys were hard and brittle, but he cut small rods out of them with a hack saw and filed them to dimension. When measured against copper, the gratifying fact was found that a large negative electromotive force was generated, largest for about 10% chromium. Here was the discovery of "Chromel," one of our standard base-metal thermocouple wires. Likewise it was necessary to know the electrical resistance of these new alloys, which, when measured in a Wheatstone bridge, gave unexpectedly high values. Young Marsh was now on the trail of the durable heating elements required for electrically heated equipment of all sorts.

Other important things that these experiments proved was that he would need more adequate experimental equipment, a little financial backing, and some connections with progressive business men, so in May, 1904, Marsh joined the staff of Mariner & Hoskins (then a leading firm of consulting chemists in Chicago) on a small salary — very small — and a percentage of the profits, if any, from his discoveries.

First came the practical problem of melting these interesting refractory alloys in rather larger quantities. The coke-fired cupola was just endurable, but in 1904 only the crudest of electric furnaces were in existence. So the young inventor set his mind to this problem, and conceived the idea of heating a small hearth furnace by means of a stack of ¼-in. carbon plates through which electric current was passed. Conductivity of such a resistor (and therefore temperature control) was regulated by squeezing this pile to a greater or less degree with a hand screw. Proper refractories were discovered and operating details were successfully worked out during the further melting of chromium-nickel alloys, and in 1905 the Hoskins Manufacturing Co. was organized to build and sell this electric furnace. This it did successfully, and this type of electric furnace was of "first aid" to investigators working on high temperature problems for many years. The research was already commencing to pay its way!

Meanwhile attention had been concentrated on the electrical resistance of the new alloys. Enough demand for heating elements had already appeared to prove that a great future was ahead of some improved metallic resistor. In 1905 there was available a series of nickel-copper alloys with fairly high resistance (about 50 times copper), but which were almost valueless as heating elements, for they burned out in 15 min. or less at 1800° F. There was also a series of iron-nickel alloys with 85 times the resistance of copper and a life of 100 to 150 min. at 1800° F.

What Marsh was looking for was a ductile alloy which had even higher resistance and several times the life. This he discovered in a family of alloys containing more than 75% nickel and less than 25% chromium, and a patent covering them was issued on Feb. 6, 1906 (No. 811,859).

Manufacturing Difficulties Overcome

This, however, was only the beginning — an introduction to the metallurgy of the nickel-chromium system, so to speak. Alloys made of best nickel and chromium, even when melted in the carbon resistor furnace, would carry up to 1% iron as an impurity and so much carbon that the rods could be drawn to wire only with frequent annealings. Their high content of nickel bequeathed all the casting difficulties of that refractory metal. Chromium metal, reduced by thermit reaction, was the lowest in carbon then available; eventually sources of raw materials and manufacturing technique were found which produced sound ingots, malleable enough to work, after their rough surface had been machined off, down to sound metal. These experiments were performed in a small plant in Evanston, Ill., where power was available for melting. Marsh would work there all day, making a new alloy, then go back to the Chicago laboratory and measure its properties in the evening.

Now that the firm knew how to make wire, strip and sheet of the new resistance alloy it seemed desirable to reorganize the company. It was moved to Detroit and capital secured to build a small plant. It was a characteristic thing for Albert Marsh to insist that Mr. Hoskins' name be not replaced by his own in the new firm's name — "It will please the old gentleman, and it makes no difference to me." The most cordial relations existed between these two men up to Hoskins' death at an advanced age last year.

History of the Detroit organization is a continuous and victorious struggle to improve quality, even while increasing production. It was obvious that melting in an induction furnace would control the undesirable carbon far better than could be done in the carbon resistor furnace. Therefore a ring-type furnace was installed (one of the first Kjellin furnaces in America) and used for many years. At the present day all melting is done in a pair of Ajax high frequency furnaces of about 500 lb. capacity, each melt requiring about 50 min. and producing three 160-lb. ingots. Surely a long way from a 5-lb. button melted with difficulty at the end of a day's hard firing!

In the first operations the small ingots were machined and then cold rolled into wire rod, the rolling being frequently interrupted with long annealings. With the advent of the induction furnaces and large ingots, Marsh decided that a hot mill would be required. So a merchant mill of the Belgian type was bought and installed. The head roller still likes nothing better than to tell stories about how a mountain of scrap accumulated while Mr. Marsh worked day and night practically continuously for a couple of months until all the troubles in this totally untried process had been removed — how he drove his crew so hard they all but mutinied. None of those men have lived to regret those exhausting weeks. (It might be remarked in passing that scrap from the wire works forms the principal raw material for high nickel-chromium heat resisting castings — a fortunate outlet, for it cannot be successfully remelted into ingots for really high grade resistance wire.)

Final Recognition

Others, outside his own organization, tried this mettle in a patent suit fought and won against powerful infringers. Not until 1914 was final verdict rendered, and was it established that the original Marsh patent for nickel-chromium resistors was valid and the imitations then on the market were substantially the same in all physical properties and varied only slightly in chemical composition.

One might think that Marsh might rest on his oars when extensive researches, within his organization and his competitors', had failed to discover alloys superior in electrical characteristics to the 80-20 nickel-chromium resistors patented in 1906, together with strength, ductility and life at high temperatures. However, a visit to the Hoskins plant today will show numberless details where improvement is still going on. Annealing processes have been highly developed to produce rod and wire with superior drawability and excellent surface. The same basic analysis has been retained but improved by details of melting, refining, and processing, so that life of the resistors in the standardized test is more than twice as long as what was considered good five years ago.

All this without fanfare for the smiling gentleman whose photograph illuminates this article, and whose confidence comes from long years of struggling with fractious metals, bending them at his will to serve the changing needs of modern civilization.

COLD FINISHED BARS

properties & applications

by J. D. Armour
Metallurgist
Union Drawn Steel Co.
Massillon, Ohio

ANY COMPLETE CONSIDERATION OF "COLD finished bars" should say something of the method of processing, although most metallurgists are more interested in their properties and uses. It is generally understood that the raw material for the regular sections (that is, rounds, hexagons, squares and flats) is hot rolled bars of the same shape but sufficiently oversize to allow for whatever draft is required to make the particular item. The amount of draft will vary considerably for different requirements, but in the majority of cases it is about 1/16 in. on the diameter or thickness. Sometimes these bars require annealing to develop some definite microstructure, and this is usually done in a car-bottom type of furnace, special attention being given to the method of loading and spacing between small bundles so that heating will be uniform.

Cold finished bars may be divided broadly into three classes according to the method of processing — (*a*) turned and polished, (*b*) ground and (*c*) cold drawn. The latter will be the principal one considered.

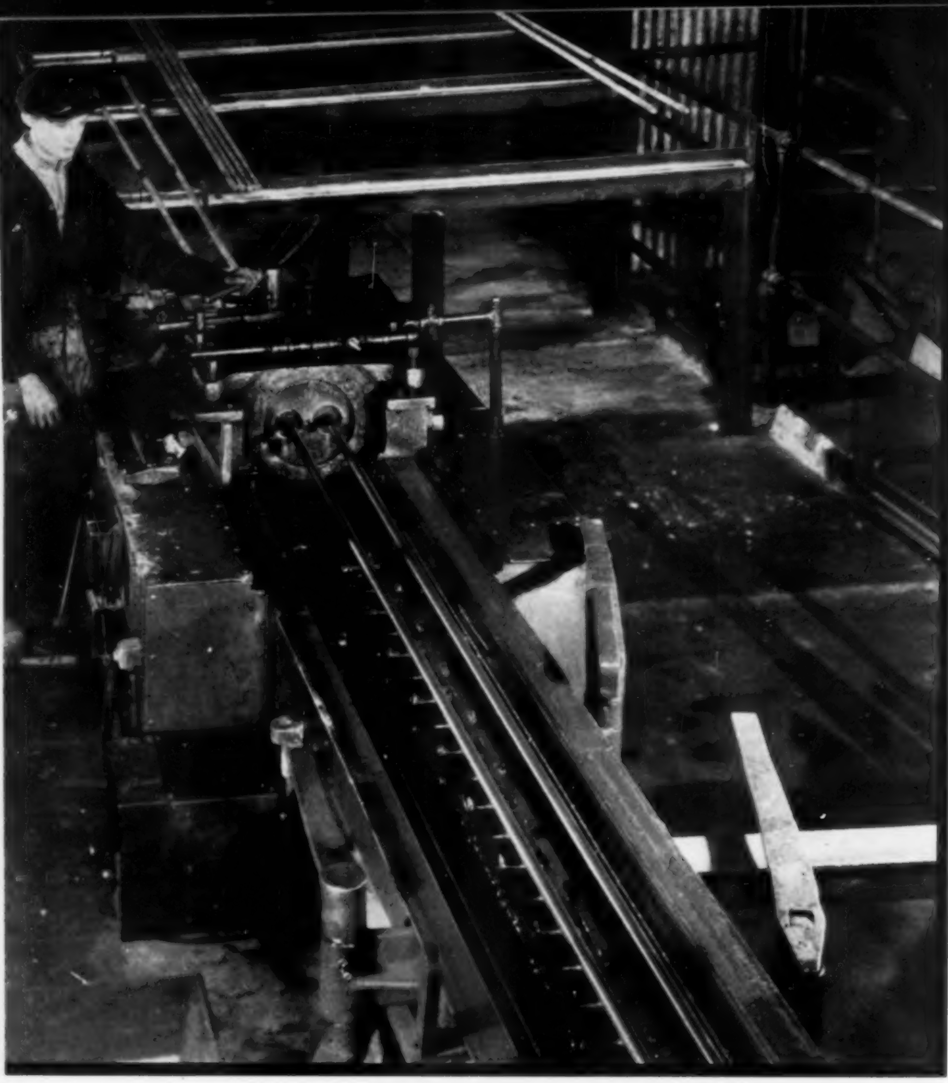
Turned and polished bars can be made in sizes ranging from about 1¼ in. to 8 in. round. This method of processing is used when hot rolled physical properties are desired in the finished bar, when it is desired to remove all of the slight surface imperfections which are invariably found on hot rolled bars, or when the size is too large to be satisfactorily cold drawn (over about 3-in. round).

Grinding bars to size is resorted to when it is necessary to have a perfect surface, exceptional concentricity, and very close tolerance on size. For certain requirements, such as pump rods, ground bars are furnished straight within 0.005 in. indicator reading in a 20-ft. bar. Both cold drawn and turned bars are finished to size by grinding, depending on whether cold drawn or hot rolled physical properties are desired in the finished product. Ground bars can be furnished in sizes from ⅛ in. to 8 in. round.

While turned bars and ground bars are important classes of cold finished bars, the bulk of the tonnage is cold drawn. The fundamental processes of cold drawing bars have not been changed since the inception of this method some 50 years ago — the bars are pickled in acid to remove scale, drawn through a die to accurate size, and then straightened and cut to length.

Change in Process and Properties

Although the fundamentals have not been changed, great strides have been made in the mechanization and refinement of the processes. The first halftone shows a modern drawbench equipped for drawing two bars at a time. To the cold drawing man this bench presents about the same contrast to the original model as a 1900



Modern Draw Bench With Two Dies in Single Holder. Note levers for transferring finished bars from bench to trestles

automobile compares to the latest streamlined creation. The second cut shows a modern Abramson straightener and exhibits a similar order of improvement.

Cold drawing is the only operation, aside from annealing, that produces a marked effect on the physical properties of our product. The effect of cold drawing will now be considered in two representative cases. The top part of the table on this page shows it for a soft open-hearth steel containing 0.16% carbon, 0.72% manganese, 0.019% phosphorus, and 0.035% sulphur. The effect, it should be noted, is deep seated and not merely a surface effect, as the tests were on standard 0.505-in. tensile pieces machined from the bars.

The ultimate strength has not increased nearly as much as the yield point, but that is not so important because for most applications a part would be useless if it were stressed beyond its yield point and permanently distorted. Elongation and reduction of area have been reduced considerably, but the values would be sufficient for the majority of applications where a yield point of 90,000 psi. is required.

To get the same yield point without cold drawing it would be necessary to go to an alloy steel or resort to heat treating. Compare the physicals of this same bar with 15% reduction by cold drawing and a bar of S.A.E. 3135 alloy steel heat treated to approximately the same yield point by quenching in oil from 1500° F. and drawing to 1200° F., as shown in the second part of the table. The cold drawn carbon steel bar would be cheaper in first cost and easier to machine than the heat treated bar, and for many applications would give just as good service. Other consumers would do well to follow the lead of automobile companies and take advantage of this feature of cold drawn steel.

Of course, the cold drawing operation produces a similar effect on higher carbon steel and

Effect of Cold Drawing on Mechanical Properties

Condition	Yield Point	Ultimate Strength	Elongation in 2 In.	Reduction of Area	Brinell Hardness
0.16% Carbon Open-Hearth Steel					
Hot rolled bar, 1 3/32 in.	44,500	69,250	37	65	137
Reduced 5% to 1 1/16 in.	61,050	81,750	19.5	58	170
Change	+35%	+18%	-47%	-10%	+24%
Reduced 10% to 1 1/32 in.	84,500	88,250	16.5	56	179
Change	+90%	+27%	-55%	-13%	+30%
Reduced 15% to 1 in.	90,100	94,250	15.5	55	187
Change	+102%	+36%	-58%	-15%	+36%
0.35% Carbon, 1.25% Nickel, 0.60% Chromium Steel					
Heat treated bar, 1 in.	89,150	107,900	26	67	228
Hot rolled bar 1 1/16 in	102,500	131,550	15.5	41	248
Same, reduced 10% to 1 in.	116,150	146,050	9.5	35	262
Change	+13%	+11%	-32%	-14%	+5%

alloy steels, although not as pronounced, especially if the steel has not been put into its softest condition by annealing before cold working. Note the figures toward the bottom of the table for S.A.E. 3135; after a draft of 10% the yield point has been increased 13% as compared to a 90% gain in the case of the 0.16% carbon open-hearth steel.

This serves to illustrate the fact that different steels have different capacity for cold working—in fact, the same steel will have a widely varying capacity depending on its prior physical condition. In general we can say that any steel will have its greatest capacity for cold working when it is in its softest condition (that is, fully annealed) and, as the original hardness of the bar before cold working is higher, its capacity for cold working is lower until a point is finally reached where the cold drawing operation does not raise the physical properties of quite hard steels at all. The table contains an example of a steel that approaches the physical condition where cold work would have no effect on raising its hardness and strength.

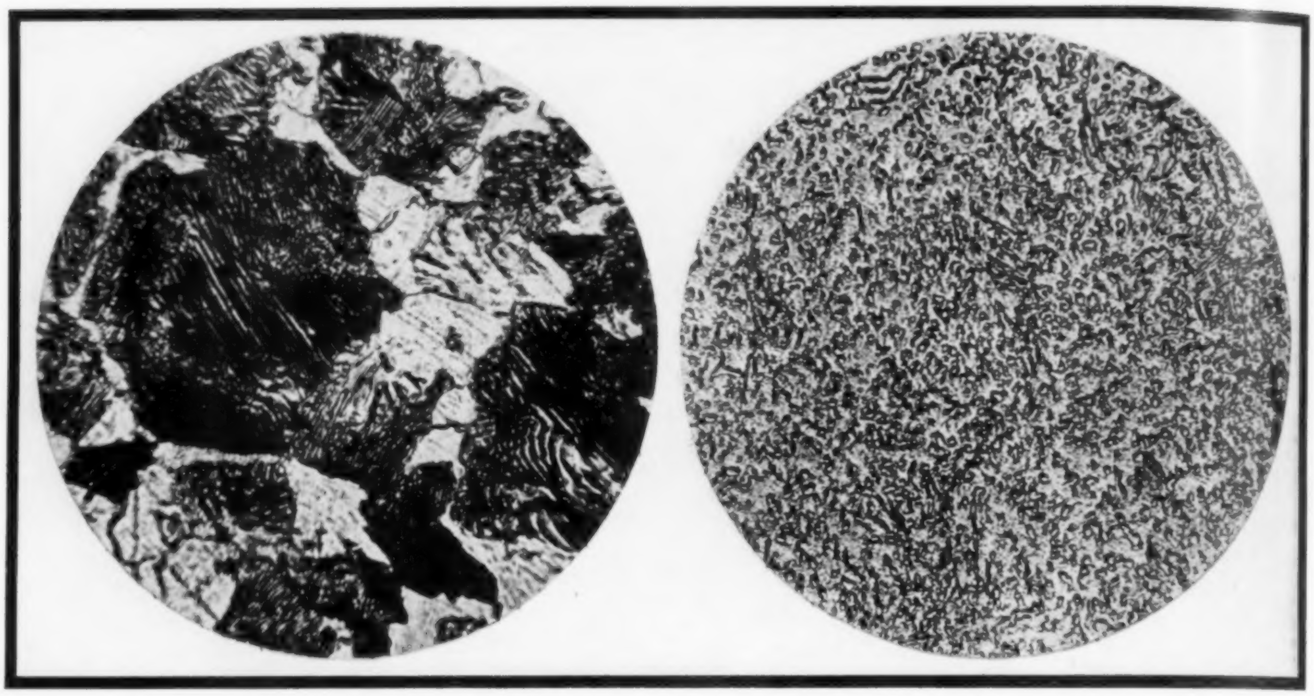
Machinability

One of the most important requirements of cold finished bars is good machining properties. This has received a lot of attention during the past few years; in fact, a great deal of progress has been made in improving machinability of *all* types of steel.

It is convenient to divide the steels roughly into two classes, the high sulphur steels, and the low sulphur steels. All of the really fast machining steels are high in sulphur (that is, over 0.10% at least).

While there have been some statements in the literature in the last few years that might lead one to believe that sulphur was of secondary importance, nevertheless we still feel there is nothing like good old manganese sulphide to promote fast machining properties, and the higher the

Abramson Straightening Machine, Wherein Spinning Bar Advances Between Conical Rolls, Properly Inclined and Spaced



Cleanly Separated Pearlite and Ferrite Gives Best Machinability for Soft Carbon and Alloy Steels. In medium steels the pearlite preferably contains a few particles of globular cementite (S.A.E. 3140 at 750 diameters at left). In higher carbons the cementite should be thoroughly spheroidized for automatic screw machine work (S.A.E. 6150 at 1000 diameters)

sulphur content, up to at least 0.50%, the faster the steel can be machined. Of course, the question of tool life is another angle. It is possible to have a steel that machines easily, but dulls the tools quickly. Anything in the steel of an abrasive character will tend to reduce tool life, and everything should be done to keep the abrasive type of inclusions to a minimum.

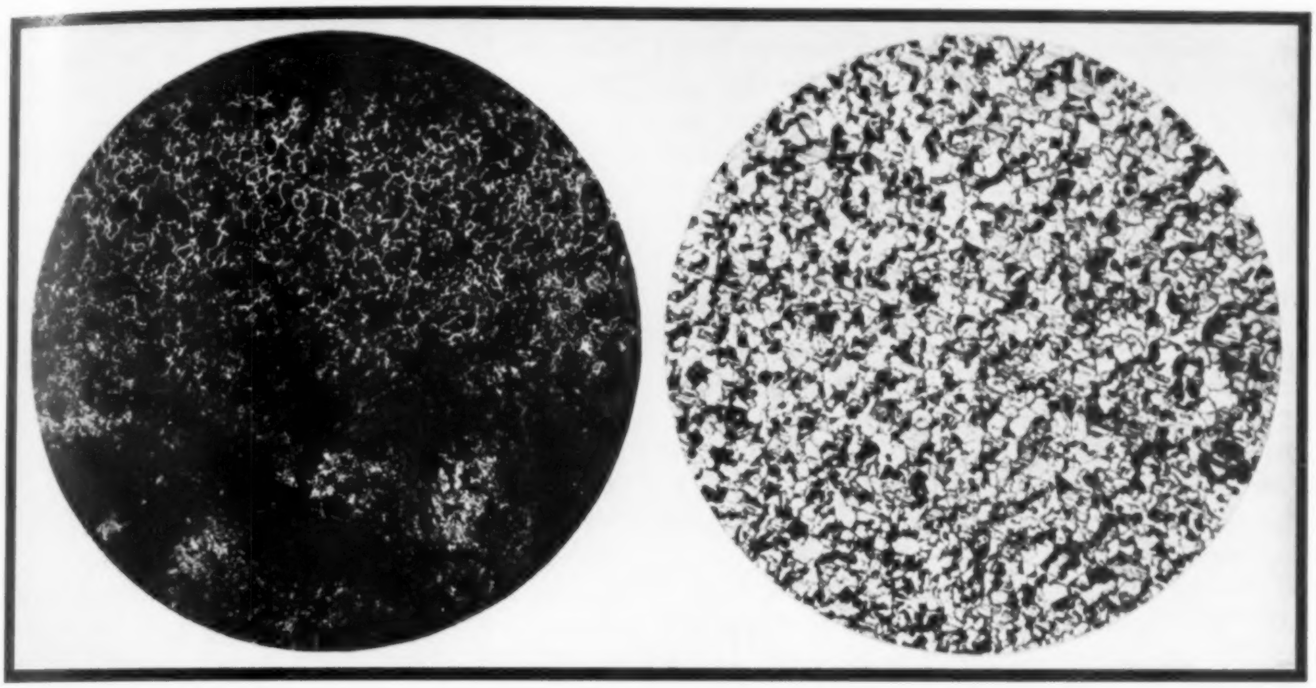
In the low sulphur steels, both carbon and alloy, we have a different type of problem. Low sulphur steels at best will not machine anything like the high sulphur types, but nevertheless there is much that can be done to improve their machining properties. If the steel is low in carbon and "drags" in machining because it is too soft, we can cold work and reduce the ductility to the point where it will machine much more satisfactorily.

On the other hand, with the higher carbon steels the best line of attack is to heat treat to the correct type of structure. We have found a clear-cut structure with ferrite and pearlite cleanly separated, and with the pearlite distinctly lamellar, to be very suitable for automatic screw machine work on the higher carbon, straight carbon steels. In the alloy steel lamellar pearlite with just a suggestion of spheroidization seems to machine a little better. This is shown in the left view of the pair on this page, representing a sample of S.A.E. 3140 which works particularly well in automatics. When carbon reaches about 0.50% in some of the alloy steels and over about 0.60% in the straight carbon steels a spheroidized structure such as the right-hand view machines very well on automatic screw machines. For some other types of operations, however, like gear cutting or broaching, this structure would not be so good.

Steel for Carburizing

So much for the question of machinability; now consider some of the developments in cold finished steels for carburizing. Up until about 1922 the majority of carburized parts were made from S.A.E. 1020 steel. Some alloy steel was used for very important parts, and a little bessemer screw stock was used where carburizing properties were of secondary importance and it was necessary to have a reasonably free machining steel. However, 1020 was difficult to machine, and wouldn't always harden right after it was correctly machined and carburized. In short, carburized jobs meant plenty of trouble all around.

It was just about this time that McQuaid and Ehn published their work on normal and abnormal steels and gave us the first idea as to why



Case and Core of Fine Grained S.A.E. X1020 After McQuaid-Ehn Test at 100 Diameters

some heats of steel hardened so satisfactorily and other heats (of the same chemical composition in the usual elements) gave so much trouble. A short time after this it was possible to buy "guaranteed normal steel" or "McQuaid-Ehn test steel," and this took a lot of the grief out of the carburizing jobs.

About this same time there was another development in carburizing steels that perhaps was as important as McQuaid and Ehn's discovery — the development of high manganese open-hearth screw stock. It was developed primarily as a faster machining type of open-hearth steel, but it was soon found that it was excellent for carburizing — in fact, the user could forget about normality, abnormality and soft spots. Since this high manganese screw stock answered both the machining problem and the carburizing problem, it increased in use very rapidly at the expense of S.A.E. 1020, and is contained in the S.A.E. specifications recently issued at X1314 (1.00 to 1.30% manganese) and X1315 (1.30 to 1.60% manganese). But while it filled a great need it still left something wanting for applications where a high sulphur steel was objectionable; also, in thin sections the high manganese screw stock was found to be quite brittle.

Within the last few years a low sulphur steel, with manganese in the 0.70 to 1.00% range and fairly high in silicon (around 0.20 to 0.30%) has been developed which meets this need. This type of steel is now being made both coarse and fine grained. It machines more satisfactorily than S.A.E. 1020, carburizes without difficulty, has high core strength and (when fine grained) it is very tough and approaches very closely some of the alloy steels. The last pair of micros show the case and core structure of this fine grained "modified 1020" type (the new S.A.E. X1020) after the standard McQuaid-Ehn test.

All three of these straight carbon carburizing steels (normal type of S.A.E. 1020, the high manganese screw stock type and the fine grained modified 1020 type) have their field of usefulness, and I think we would not want to get along without any of them. Together with the alloy steels, they give a wide selection of carburizing steels both with regard to price and heat treating characteristics and make it fairly easy to select a suitable steel for the kind of job in hand.

Cold Heading Wire

Another product which is of great importance is cold heading wire. It is used in both straight carbon and alloy steel in carbon ranges running up to 0.50%.

One of its important features is the correct coating required if the heading operation is very severe or if there is any extruding to be done. Otherwise, the wire will seize or gall the heading die, and ruin it in short order. This coating must adhere very tightly or it will be rubbed off under pressure.

One type of coating is made by rusting the wire after pickling and then using a metallic soap powder as the drawing lubricant. This type of coating is old and is called "sull coat." Another type is made by dipping the pickled wire in thick lime water to get a heavy coating of lime on the wire and then cold drawing with metallic soap powder as the lubricant. Others are more in the nature of lacquers — in fact, each cold heading plant has its pet type of coating to which it frequently attaches a lot of mystic virtues, but the answer is that any of the coatings is satisfactory if it is tightly adherent to the wire, and none of them is satisfactory if it is not. How tightly the coating adheres depends on the skill exercised in the particular mill that manufactures the heading wire.

In the harder steels (from 0.30 to 0.50% carbon) success depends not only on the coating, but also on the microstructure of the metal. Two types of annealing are then used — normalizing and spheroidizing. The normalized structure is best for carbon steel wire if the part is to be trimmed and threaded after heading because it has better machining properties, but for some very severe heading jobs even on carbon steels the spheroidized type of structure is necessary. Alloy steels must be spheroidized or they are likely to be too hard for cold upsetting.

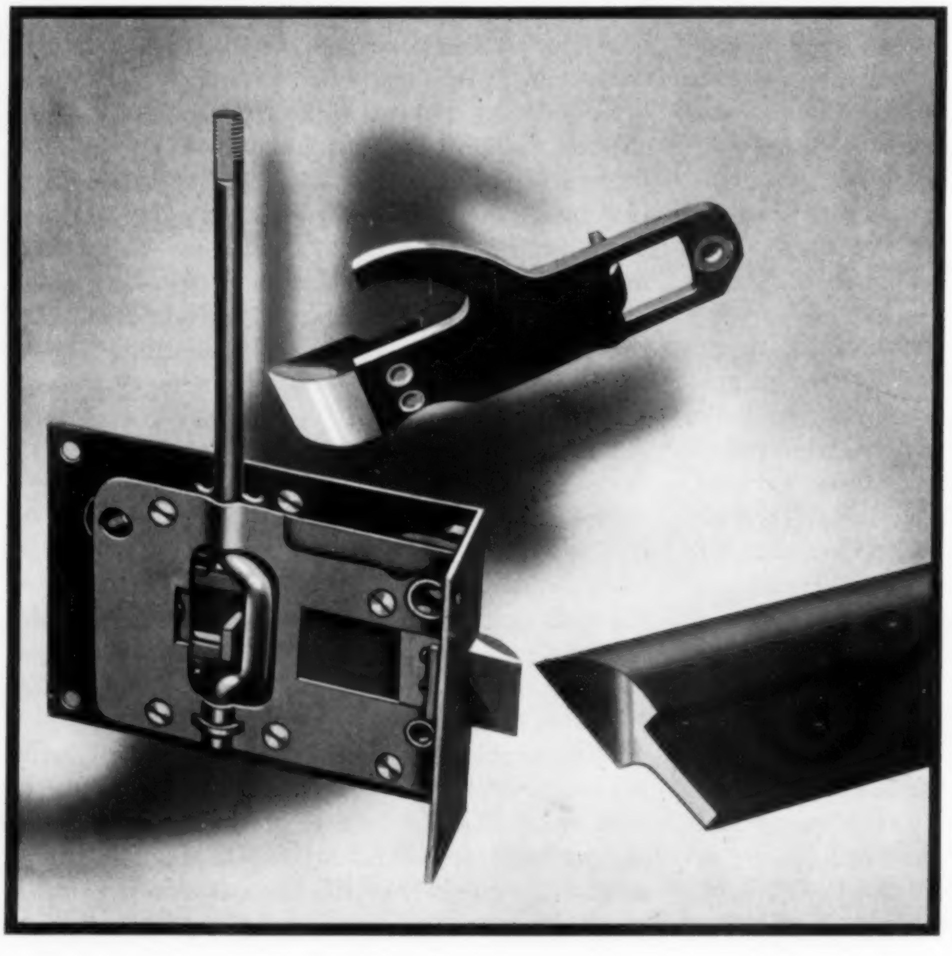
Special Sections

It is surprising how many parts can be made to advantage from cold drawn bars of special section rather than using a casting, a forging, or machining the part from a bar of regular shape.

This branch of the industry has been developing very rapidly in the past few years as manufacturers realize its possibilities. The delay is because one has to acquire a certain skill in detecting possible special sections, but after finding one or two parts in a machine or a device that can be made from special section bars it is usually fairly easy to determine whether other parts can also be made to advantage this way.

The last view shows one of the many examples in use today. These pieces are, of course, made by cutting short pieces from the long bar and then doing whatever machining and fitting may be necessary to complete the part.

Entirely aside from the advantages of surface and structure, relatively small lots of such sections can be produced much more economically by cold drawing than by any other means, as it costs far less to make the necessary series of dies and mount them on a draw bench than it does to turn a set of rolls and mount them in a mill. Of course, the unit cost is less on large orders as the preparatory costs can be spread over a larger poundage or tonnage. Ordinarily a round or flat bar would be hot rolled to a shape roughly similar to the desired cross-section in a small hand mill, and then reduced to exact size and shape in one to five or six dies, depending on its complexity.



Piece of Special Section Cold Drawn Bar, Riveted to Stamping, Makes Latch on Auto Door Lock

NOTES ON 29-9 ALLOY

castings to resist heat & corrosion

by R. J. Wilcox
Chief Metallurgist
Michigan Steel Casting Co.
Detroit

A CLASS OF HIGH CHROMIUM-NICKEL CASTINGS that occupy a very important and unique position in the heat and corrosion resisting field has chromium ranging from 26 to 30% and nickel from 8 to 14% (depending on the particular application for which the casting is to be used). The carbon content ranges from 0.20% in the corrosion resisting alloy to 0.60% in the heat resisting alloy. This class may conveniently be spoken of as "29-9."

The alloy in the range of 28 to 30% chromium, 8 to 10% nickel, and 0.20 to 0.30% carbon has been found to be very dependable in the cast condition when installed in corrosion resisting applications. A satisfactory chemical specification is: Carbon 0.20 to 0.30%, manganese 0.55 to 0.75%, silicon 0.75 to 1.25%, nickel 8.00 to 10.00%, chromium 28.00 to 30.00%, sulphur 0.05% max., and phosphorus 0.05% max.

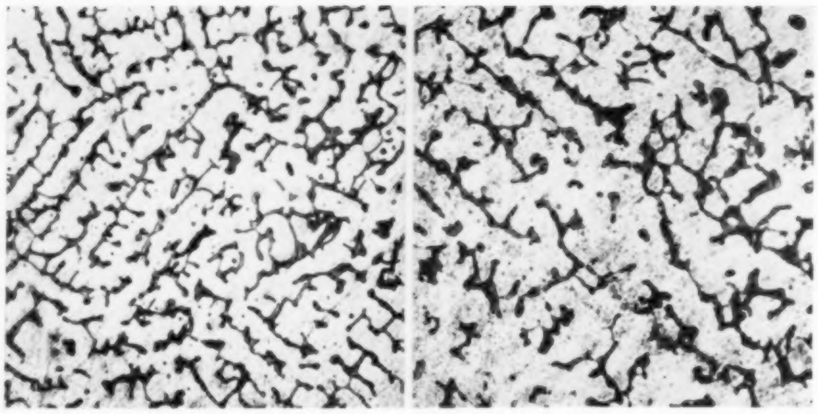
Microstructure of such an alloy consists of ferrite, austenite, and free carbides. This composition falls in the ferritic field of Bain and Griffiths' tri-axial diagram of the iron-nickel-chromium system. (See METAL PROGRESS for last October, page 52.) The extent of each phase present will depend largely on the carbon content and the rapidity of cooling either from the casting temperature or subsequent heat treating operation. As might be expected, the higher carbon alloys are more completely austenitic than the lower carbon material; on the other hand, cooling rapidly from 2000° F. will develop more ferrite (perhaps delta iron) than is ordinarily present in the as-cast condition. Microstructure of typical samples is illustrated on the next page.

One of the most valuable characteristics of the 29-9 cast alloy in a carbon range of 0.20 to 0.30% is its remarkable resistance to intergranular attack in the as-cast condition, comparable to that developed by fully heat treating the very low carbon 18-8 castings. By cooling the 29-9 alloy rapidly from 2000° F. its resistance to corrosion is still further improved. (An increase in ductility is also noted after such a high temperature quench.) However, in commercial practice it has generally been found satisfactory to use the material in the as-cast condition.

Greater Stability As Cast

This characteristic has made 29-9 particularly useful in cases where castings, because of their size or design, cannot be effectively heat treated. It is also a distinct advantage in welded structures where stainless castings are used to form part of a unit that cannot be heat treated and quenched after welding.

A comparison of the relative corrosion of the cast 29-9 alloy and the cast 18-8 alloy may be made from laboratory tests on welded samples



Structure of Cast 29-9, Etched With Aqua Regia in Glycerine and Magnified 100 Diameters. Structure as cast shown at left; same after quenching in water from 2000° F. at right

exposed for 72 hr. to a boiling solution of 3% copper sulphate and 10% sulphuric acid and bent into U-shape. This acidified copper sulphate causes rapid deterioration of stainless steels susceptible to intergranular attack. The pair of specimens at the left in the cut at the top of page 51 are low carbon 18-8 and the pair at the right are cast 29-9 alloy. Each sample was first welded transversely through the center with welding rod of substantially the same composition as the casting. It will be seen that neither sample of 29-9 at the right developed intergranular brittleness, while the low carbon 18-8, as cast, indicates such attack by fractures along the edges at the bend.

Comparative corrosion rates of the same materials are shown in the diagram on page 51. The test was made in boiling nitric acid in a flask equipped with a reflux condenser, as described by W. R. Huey in *Transactions*, vol. 18, p. 1126. Each specimen was examined and weighed at five 48-hr. intervals, being retested each time in fresh acid. It will be noted that 18-8 in the cast condition is rapidly attacked in spite of its low carbon content (0.06%), while the 29-9 alloy in the condition as cast falls quite close to the quenched 18-8. Heat treated 29-9 indicates the lowest rate of attack of the four materials tested, losing little in any after the first 2-day period.

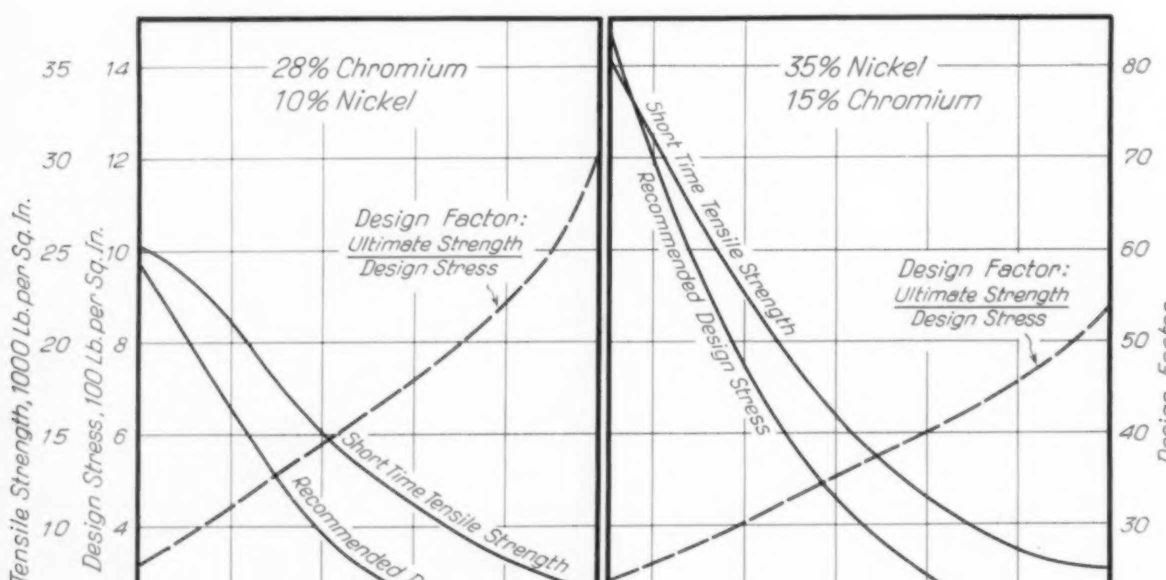
Cast alloy containing 29% chromium and 9% nickel has satisfactory tensile properties — a somewhat higher yield and ultimate strength, with somewhat lower ductility than cast 18-8.

At the bottom of page 51 are tabulated the values obtained from five typical heats. Tests were made on standard tension bars in the as-cast condition; quenching from high temperatures will increase the values for elongation and reduction of area.

Hardness in the as-cast condition is usually between Rockwell B-90 and B-95. In this condition it is more readily machinable than many other stainless cast materials.

Additions of 2 to 4% molybdenum have been studied experimentally. It has been found to increase the resistance of the cast alloy to sulphuric acid. Molybdenum additions of approximately 3% seriously reduce ductility in the cast condition.

Small amounts of titanium do not appear to have any appreciable effect on physical properties. Selenium has been used experimentally to determine its effect in developing nonseizing or free-machining characteristics, but it does not appear to effect the same degree of improvement in 29-9 cast alloy as is claimed for this element when added to other stainless rolled products.

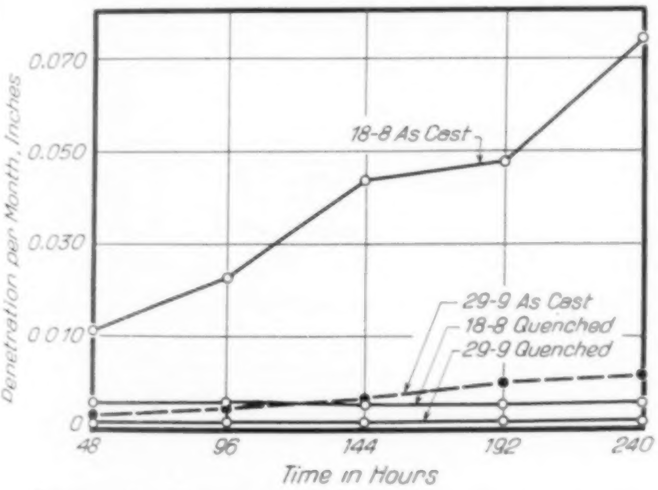


***Comparison of Design Stress Suitable for Two Important Alloys in High Temperature Service.** Read design stress against extended scale at left, which gives data based on long observation of working parts, dependable for upwards of 10,000 hr. with negligible permanent deformation*

This alloy lends itself admirably to economical and consistent melting and foundry routine. Since it is suitable for all applications in a relatively higher carbon range than the other stainless alloys, it is somewhat more fluid and easier to pour in thin sections and castings of intricate design. Therefore it has been found possible to produce 29-9 in cast shapes at a somewhat lower cost than the very low carbon 18-8 alloy, despite the higher alloy content.

Welded Castings, Boiled 72 Hr. in Acid Copper Sulphate and Bent. Left pair contained 18.1% Cr., 9.4% Ni, 0.06% C, 1.6% Si, and cracked along edges. Right pair contained 28.5% Cr, 9.9% Ni, 0.22% C, and 0.9% Si, and did not crack. Second and fourth bars were water quenched from 2000° F. before testing

The same precautions are necessary in the foundry when handling 29-9 as in the manufacture of other stainless and heat resisting alloys. From his knowledge of solidification and feeding characteristics the foundry engineer is usually capable of offering valuable assistance to the mechanical designer and draftsman in working out the details of section and shape for the most economical method of casting.



Comparative Corrosion Rates of Cast and Heat Treated 18-8 and 29-9 (Same Materials as Shown Above)

The material is readily welded with the metallic arc, using a coated electrode of the same composition as the casting.

The 29% chromium, 9% nickel cast alloy can be used to resist the same general types of corrosion in the as-cast condition that the heat treated 18% chromium, 8% nickel alloys resist.

The sulphite and paper industry has used a considerable tonnage of it in the form of valves, fittings, pump parts, and pipe connections which are required to resist the corrosive action of calcium bi-sulphite liquor. The material has shown a remarkably good service record.

Castings of 29-9 are also useful in such industries as the following: Marine work for resisting salt water corrosion; the rayon industries; chemical industry for various parts exposed to the action of hot sulphur dioxide, nitric acid, phosphoric acid, and some of the organic acids such as citric and lactic. The alloy should not be used in the presence of more than very small amounts of hydrochloric and sulphuric acids.

Heat Resistance

For high temperature service this alloy is made with higher carbon and nickel contents, and usually within the following limits: Carbon 0.30 to 0.60%, manganese 0.55 to 0.75%, silicon 0.75 to 1.25%, chromium 26.00 to 30.00%, nickel 8.00 to 12.00%, sulphur 0.05% max., and phosphorus 0.05% max.

The ductility of such material at room temperature is considerably lower, due to the higher carbon content. It generally has sufficient toughness and resistance *(Continued on page 66)*

Properties of 29-9 Cr-Ni Alloy, As Cast

Heat No.	Analyses of the Bars					Tensile Properties			
	Chromium	Nickel	Carbon	Manganese	Silicon	Yield Strength	Tensile Strength	Elongation in 2 in.	Reduction of Area
1	28.54%	9.92%	0.22%	0.27%	0.91%	47,750 psi.	96,050 psi.	27.0%	29.5%
2	28.60	8.50	0.26	0.59	1.00	59,000	97,875	31.5	30.8
3	29.72	8.54	0.28	0.51	0.84	62,000	105,350	23.0	21.3
4	27.56	9.51	0.17	0.57	1.00	46,500	97,125	29.0	32.8
5	30.34	11.00	0.33	0.77	1.10	49,000	97,650	28.0	28.5

GRINDING CRACKS

how they look

how to avoid

by Adam M. Steever
Vice-President & Technical Director
Lindberg Steel Treating Co., Chicago

MANUFACTURE OF DIES AND TOOLS FOR punching, forming and cutting requires carefully selected tool steels, accurate tools for machining and grinding and extreme care in heat treatment and finishing. It is a comparatively uncommon occurrence for a tool room to produce several sets of dies from a single drawing, and therefore all concerned in the job must draw upon former experience with more or less similar work in order to avoid trouble before the first edition of the part is finished. The experience gained on repetitive work is lacking, and except in the case of relatively simple and frequently met dies, like bolt heading dies, there is little or no opportunity to develop the best heat treating and grinding technique by trial and error and by adequate life records of the finished parts in normal production.

Especially is this true of the most of the die work which reaches a commercial heat treating establishment. Every conceivable combination of steel, size, shape and contour will be encountered; frequently the die will obviously have been designed with a single eye upon the operation it is expected to perform in service, and little or no thought given to the difficulties that may be encountered in hardening the surface correctly without endangering it from unavoidable hardening strains. Sometimes the only things that save the dies are ingenious tricks of experienced workmen.

After they are designed, the usual program in the making of such dies and tools is as follows:

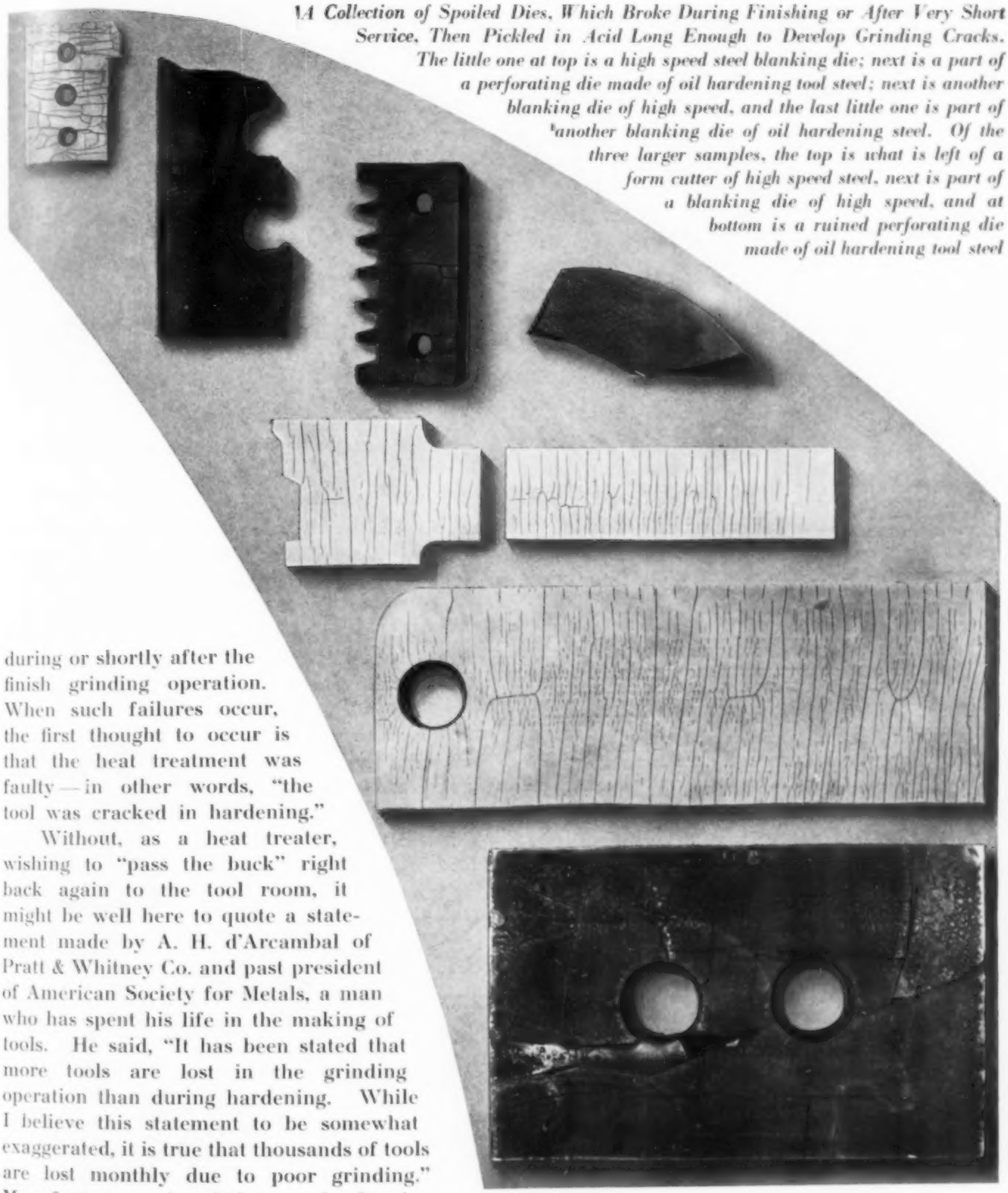
1. Selection of material,
2. Layout,
3. Rough machine and grind,
4. Heat treatment,
5. Finish grind, polish, and lap.

The first four operations are usually the most expensive because they cover the cost of material, labor and heat treatment. Labor is the preponderating item, not only because a complicated die is a lengthy job for a skilled mechanic, but also because most book-keeping methods figure overhead as a proportion of the labor cost — frequently as much as 200%.

Danger in Final Operation

The fifth or last operation is usually the most important because it requires careful grinding, polishing and sizing. Obviously it would be fatal to relax on supervision in this last step, or entrust it to any but the best available man, else the whole effort and expense be wasted.

Nevertheless, many plant managers have experienced losses and delays due to short life of dies and tools. Sometimes they break after a few hours of service. At other times tool makers have to report that dies have broken or cracked



A Collection of Spoiled Dies, Which Broke During Finishing or After Very Short Service, Then Pickled in Acid Long Enough to Develop Grinding Cracks. The little one at top is a high speed steel blanking die; next is a part of a perforating die made of oil hardening tool steel; next is another blanking die of high speed, and the last little one is part of another blanking die of oil hardening steel. Of the three larger samples, the top is what is left of a form cutter of high speed steel, next is part of a blanking die of high speed, and at bottom is a ruined perforating die made of oil hardening tool steel

during or shortly after the finish grinding operation. When such failures occur, the first thought to occur is that the heat treatment was faulty — in other words, "the tool was cracked in hardening."

Without, as a heat treater, wishing to "pass the buck" right back again to the tool room, it might be well here to quote a statement made by A. H. d'Arcambal of Pratt & Whitney Co. and past president of American Society for Metals, a man who has spent his life in the making of tools. He said, "It has been stated that more tools are lost in the grinding operation than during hardening. While I believe this statement to be somewhat exaggerated, it is true that thousands of tools are lost monthly due to poor grinding." Manufacturers of grinders and abrasive wheels also recognize the seriousness of the situation, and the leading concerns have published pamphlets or instruction sheets to show the tool maker how to avoid trouble from this cause.

Nevertheless, they continue to occur, as proven by the photographs of a number of ruined tools shown on this page. Metallurgical investigations made on these failures show that they result from abusive grinding, which checks the surface. A similar type of failure observed on the journals of heavy axles and crank shafts is described by Mr. Ashdown in the leading article of this issue.

These grinding cracks can be etched out very prominently by boiling *(Continued on p. 68)*

LETTERS AND COMMENT

on items of interest today

Low Frequency Induction Furnaces

TRENTON, N. J. — A letter from Hans Diergarten published in METAL PROGRESS in January described some furnaces operated in a vacuum by the Heraeus Co. for the production of gas-free metals. It stressed, especially, the idea that such melting was done in a coreless induction type of furnace drawing current from the line at normal frequency, 60 cycles per sec., more or less.

The Ajax Electrothermic Corp. owns U.S. patent 1,851,984 issued to Ivar Rennerfelt, as well as other patents which control in the United States and Canada the furnace described in the article. Thus far our corporation has not felt that the development and marketing of the furnace was justified. Some of the reasons for this view follow.

The furnace is principally adapted for liquid charges, and in normal operation a heel of hot metal must always be left in the furnace. To start such a furnace with cold metal is an exceedingly slow and difficult operation requiring several hours at best, and usually a charge containing special shaped castings.

The net power factor is very low. In order to operate the furnace from any power circuit serving other customers, condensers must be used. The cost of correcting the power factor, to say 80%, is very high, so the combined cost of the outfit is considerably greater than the cost of an equivalent high frequency furnace with its frequency changer, condensers and controls.

Efficiency of the 60-cycle coreless furnace is definitely lower than of the high frequency furnace. This is because very much higher currents must be used to produce the same heating, and also because the inherent coupling (ratio of magnetic flux absorbed by melt to total flux) is lower. This is clearly set forth in a paper by C. A. Adams entitled "High Frequency Induction Furnaces" presented before the American Institute of Electrical Engineers, January, 1934, in which he describes the cylindrical, 60-cycle, single-phase furnace.

The German furnace, as described, has water-cooled windings underneath the bath. Should a run-through occur in such a furnace, the damage done is considerably greater than in the case of the high frequency furnace where the water-cooled windings are located at the side.

Turbulence of molten metal in the 60-cycle furnace is high, and because of the low frequency used will continue to be higher than in high frequency furnaces, even when power is reduced to an amount which merely holds the temperature. This is apparent when it is realized that the 60-cycle furnace is really an induction motor with a rotor of molten metal, and the motor action is violent. This means that if the power is reduced to give a flat surface on the melt, and permit entrapped slag to rise, then

insufficient power is absorbed to hold the temperature.

Lastly, the flexibility of electrical and temperature controls on the furnace is decidedly inferior to that of the high frequency furnace.

The difficulties outlined above apply not only to the three-phase, 60-cycle furnace described by Dr. Diergarten, but to single-phase, 60-cycle furnaces as well, and would seem to be inherent in all low frequency furnaces of the coreless type. A great deal of time and money has been spent in attempts to develop 60-cycle coreless furnaces, but so far all of them with which we are acquainted have been unsuccessful.

G. H. Clamer

Corrosion of Marine Structures

Liverpool, England — In the work of the Corrosion Committee of the Iron & Steel Institute, a very serious commercial problem is being attacked by a selection of men who are not merely scientifically clever, but who have also a due appreciation of what is attainable commercially. It is, of course, quite easy to suggest building the hull of a ship of stainless steel which would probably eliminate corrosion, but the cost is prohibitive. (I say "probably" in view of troubles noted in the editorial in Metal Progress for February.)

So far as serious external corrosion of hulls is concerned one is dealing entirely with sea water. Now, given enough sea water, and time enough, its powers for ill are immeasurable. When it is diluted (for example, in estuaries) its capabilities for harm are increased. Also it is in estuaries that sewage effluents discharged from chemical works and such like are particularly potent. Conditions are by no means uniform, which makes the problem even more difficult. The writer has quite recently examined a ship that, after eight years' satisfactory service, was diverted to a route that involved a short periodical stay in a previously unvisited harbor. She immediately developed serious corrosion trouble in the stern of the ship and in both propellers!

Obviously, ordinary mild steel placed in sea water is going to corrode and the only preventive is paint. This is renewed periodically, but when a ship goes into dry dock, she normally sits on a row of blocks; she does not, therefore, get painted on the keel plate with anything like the same thoroughness as the rest of the hull. The wedges of the blocks are slipped, and the top layers of the block removed, but the conditions of working are not good enough to insure a really first class job, with the result that keel-plate corrosion is frequent and rapid. So serious is this particular problem that the production of a noncorrodible steel at anything less than a fancy price would be seriously considered by ship owners solely for keel plates. £120 per ton, or anything like it, is, of course, quite prohibitive. I should estimate that something like £40 per ton would appeal for this particular item. Whether the recently developed low alloy steel containing chromium, copper, and silicon is worth the extra price in this service will warrant investigation.

I think, however, that the metallurgist is apt to lose sight of the fearful punishment to which mild steel is subjected in this world. The production of mild steel has reached such a state of perfection that it is expected to stand anything — and in 99 cases out of 100 it does, even when handicapped by the ordinary process of riveting! Riveting is very largely a matter of brute force and ignorance, and strains are left in the rivets which make it a mechanically unsound job. The cold working of steel plates frequently leads to the production of microscopic cracks from whence cometh much evil. At the same time the fit is not perfect, sea water can enter, and the work of corrosion begins.

The usual anti-fouling paints used as an antidote of corrosion are those containing arsenic, mercury, or copper applied over a coating of anti-corrosive. Now, while from the naturalist's point of view the theory of poisoning the marine animal and vegetable is quite wrong, the fact still remains that these paints are very efficacious — especially those containing copper when exposed to waters where grass flourishes. What one is liable to overlook is that in the painting of a hull a very large area has to be covered in a short space of time, and such things as corners or heads of ill-fitting rivets are difficult to coat adequately. It is the odd bare spot which, presented to sea water in quantity, leads to trouble.

The inside corrosion of hulls is, and always

must be, an uncertain quantity. The carriage of liquid cargoes varying from benzine to palm oil will always present its problems of attack on the structure of deep tanks. Equally so, a drum of sulphuric acid which decides to leak can cause a great deal of trouble in ordinary holds! Fumigation of ships by sulphur dioxide, carbon disulphide, and hydrocyanic acid can also set up corrosion troubles in holds that are probably already saturated with sweat, and possibly fumes from other cargo.

It is my opinion that mild steel has reached its economic minimum price and the solution of corrosion difficulties must be found in paint. Development of paints has gone a long way, but more attention must be paid to the elasticity of the protective film; it is now too easily broken by a bump from a sling containing heavy cargo, where-upon sweat and perhaps fumes from cargo will rapidly do their fell work.

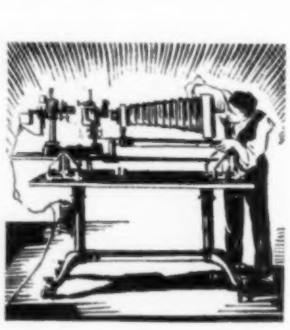
These problems are at last being attacked on the right lines. What the man who has to do the job *can* do is being considered by the Corrosion Committee without undue regard for what is scientifically attainable in a laboratory.

F. Grimshaw Martin

Globulite: Spheroidized Cementite

PRIBRAM, Czechoslovakia — As a supplement to Dr. Poboril and Mr. Koselev's discussion on the nomenclature of the various structures in heat treated steel (Metal Progress, March issue), I would suggest the use of the term "globulite" for the more unwieldy "spheroidized cementite" or the misnomer "divorced pearlite."

This proposed term describes very well the structure it represents, consisting, as it does, of globules of cementite in ferrite, and has the advantage that it gives a different name to a structure that differs from pearlite in its nature and genesis. In other words, pearlite (fine to coarse) is the result of primary cooling from above the critical. Globulite is a secondary structure, usually the result of tempering martensite, but sometimes the result of annealing pearlite.



A. Glazunov
Professor, School of Mines

Association of Flakes and Dendrites

GROSNY, U.S.S.R. — In a series of articles and letters about "flakes," published in Metal Progress last fall and winter, H. H. Ashdown took the stand, to which Soviet metallurgists will generally agree, that the most effective means of controlling flakes in steels subject to this disease is to cool the ingots or forgings very slowly. Some experiences at the Stalingrad Steel Works support this view. Alloy steel made there has been scrapped to the extent of 40% of ingot production, such regrettable records occurring in winter time. A careful study developed these facts:

If 2½-ton ingots are stripped hotter than 1300° F. and cooled in the air, a large proportion of them will develop flakes 2 to 3 in. under the skin of the upper half. Much fewer ingots are spoiled when the stripping temperature is about 1100° F.

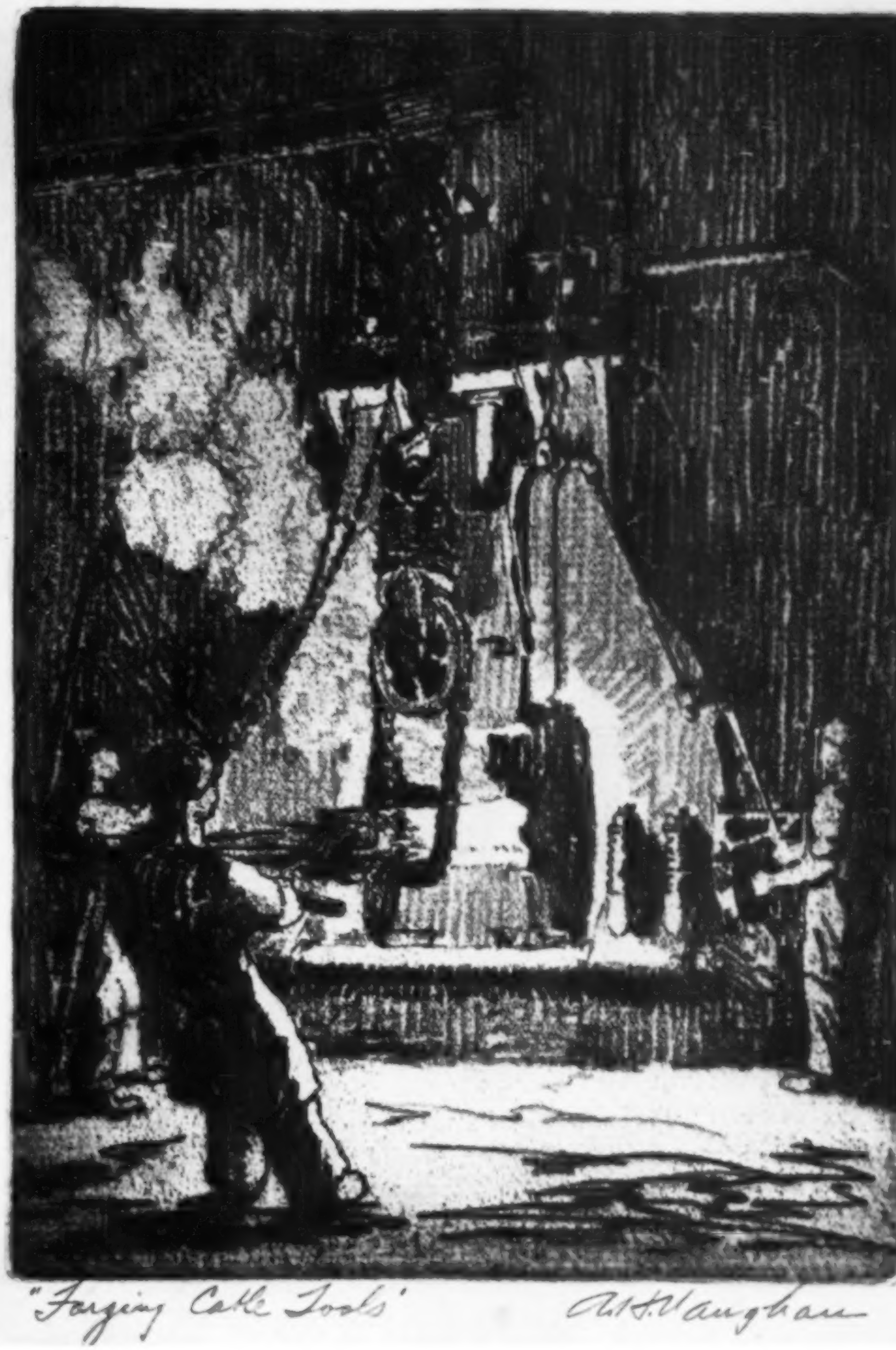
If sound ingots are rolled to 3-in. square billets or heavier, and cooled in the air, flakes are caused ½ to 1 in. under the surface at any time of the year; however, the bigger the billet and the colder the weather, the more flakes are found. Long heating without rolling or forging will not heal the defects, but either flaky or sound steel rerolled to 2½-in. diameter or smaller is sound, irrespective of the cooling rate.

With these facts in mind, ingots of susceptible steel such as S.A.E. 5140, 3140, and 3315 are now stripped at low temperatures, and reheated at a slow rate. If large billets are to be cooled, it is done in pits filled with dry sand, wherein 12 hr. is required to reach 600° F. Cooling rates of 4° F. per min. will do for less tender steels.

Flakes have also plagued the crankshaft department of the Stalingrad Tractor Works. In the ensuing investigation some S.A.E. 5140 billets, 4½ in. in diameter and known to be flaky were forged and cooled at controlled temperatures and rates. The flakes welded during forging (preheated to either 2350 or 2100° F.) irrespective of the time required to heat, ranging from 1 hr. 40 min. to 3 hr. 10 min., and the forgings were sound if cooled in dry sand. If these crankshafts were cooled in open air, small flakes reappeared, and the transverse tensile properties suffered. However — and this is important — there were no flakes in crankshafts forged from flake-free billets, even though air cooled.

Some interesting conclusions regarding the

Real ability other than in engineering is possessed by A. H. Vaughan, chief engineer of Electric Furnace Co., whose hobby is etching. This excellent industrial view was made on a copper plate by a modification of the ordinary process, so that it reproduces broad pencil strokes instead of sharp needle lines



nature of flake-free steel were reached by Prof. A. L. Baboshin of the Leningrad Institute of Metals, following a study of 38 disks for steam turbines. These were of three steels similar to S.A.E. 3430, 2330, and 5130. The metallurgist at the factory, Mr. Mihilov-Miheev, had previously examined 78 flaky disks. Of these 41 possessed a pronounced dendritic macrostructure, and the largest dendrites were associated with the largest flakes; in 16 disks the dendrites were developed with difficulty, and in 21 there were no traces of dendrites. Contrary-wise, in 70 disks free of flakes, 42 had a homogeneous (non - dendritic) macrostructure, and in only 12 did well-defined dendrites appear on the pickled surfaces.

Hence Prof. Baboshin attempted to discover the reason why flakes favored steel with dendritic macrostructure, that is, steel which has a considerable segregation of the chemical elements. He found that the microstructure of flaky disks having highly developed dendritic segregation (macroscopic) is either banded or not at all uniform; the regions corresponding to the ribs or axes of the dendrites consist of well-developed pearlite grains in a ferrite network, whereas the regions corresponding to the dendritic edges have a structure suggestive of martensite. In those steels where the dendritic macrostructure was poorly developed and with difficulty, the microstructure was all of pearlite grains in a ferrite network, but the grain size was coarser along the ribs than at the edges.

His findings harmonize with the supposition that the dendritic ribs are lower in the alloying metals and incidental chemical elements than the edges, and have a lower critical range together with a lower critical rate of cooling. This means that when a sizable forging of this non-uniform material is cooled in air, the portions near the surface cool at a rapid enough rate so that the metal in both ribs and edges of the dendrites goes unchanged through the upper arrest in the so-called "split transformation" and the most of the volume change occurs at Ar'' (700° F. or lower). However, cooling is at a slower rate toward the interior of the mass, and, even though the more highly alloyed dendritic edges are cooled at faster than their critical rate, the purer dendritic ribs transform at Ar', about 1000° F. This produces a region where transfor-

mation occurs at widely different temperatures in adjacent portions of metal, imposing large internal stresses due to the associated volume changes. This is responsible for the flakes. We also find that deep seated portions of the ingot, large billets or forgings are free of flakes because the cooling rate there is so slow that all portions transform at Ar′. The dangerous cooling rate has been determined to be within the range 4° to 22° F. per min.

This theory of the cause of flakes does not violate the known facts (*a*) that flakes are nearly always disposed along dendritic markings or in the edges where two dendrites abut, irrespective of whether visible non-metallic inclusions exist there or not, (*b*) that somewhat highly alloyed steels of the nature presumed to be along the edges have 1½ to 2 times as much change in volume at transformation as plain carbon steel (as determined by dilatometer), and (*c*) that flakes in dendritic steels may be suppressed either by *very* slow cooling or by quenching, or by enough forging to break up the continuity of the primary crystallization.

Of course, the best way would be to produce flake-free steel wherein segregation is minimized to the utmost. It is impracticable to do this by lengthy annealings and multiple heat treatments. It is more logical to look to the steel melter to produce more nearly homogeneous steel. This will be done by better control of raw materials, slag and temperature control during refining, production of a multitude of crystallization nuclei by proper additions of one or more of the elements aluminum, titanium, or vanadium to properly deoxidized steel, casting at proper temperature at a rate which will control solidification of the viscous steel, molds of correct design, stripping at low temperature and transferring immediately to soaking pits.

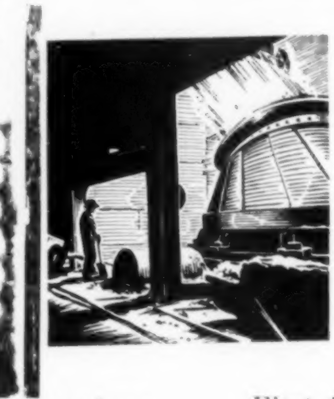
A point in this connection is the belief of many skilled melters that ferrochrome is quite viscous just above its melting point and does not diffuse readily in the bath. Owing to its ready oxidizability, it is added at the latest possible moment, and the tendency is to allow insufficient time for this diffusion. Special attention should therefore be given to the necessity of thoroughly mixing this alloy in the liquid steel, else it will be dangerously concentrated between the dendrites.

B. M. Suslov

Alexandre Pourcel
A Great French Metallurgist

PARIS, France — The publicity and acclaim that come to men and their achievements do not correspond in the least to their real value, because they depend principally on their situation, good fortune, and connections. That is why it may often happen that a discovery becomes classic, known universally, whereas the inventor's name remains unknown or is a subject of debate.

This is what happened to the dean of French metallurgists, Alexandre Pourcel, who recently died at the age of 92 years. With him one of the greatest figures disappears, and yet his name is practically unknown in the United States. His discoveries and studies have still a considerable influence upon the progress of metallurgy; his life remains a model of fertile labor, joined with great modesty.



This eulogy will confine itself to three important discoveries; any one of them should have been sufficient to perpetuate his fame:

First, he made 65 to 80% ferromanganese in the blast furnace, which had been previously prepared in a crucible or on a hearth. The price of this product, indispensable to the fabrication of bessemer steel, then fell from 1500 francs to 40 francs. He was also the first to produce and to make use of a ferro-alloy containing both silicon and manganese, now known as silicomanganese or silico-spiegel.

Second, he observed that samples taken during a bessemer blow developed white cast iron riddled with blowholes as the silicon disappeared. From this, he inferred that silicon quiets the steel, and he was the first to manufacture steel castings without blisters and blowholes by the addition of silicon. By the use of silico-manganese he also obtained compact and forgeable steel, thus explaining the essential parts played by these elements in the refining stage. He showed that by a correct heat treatment, annealing and double quenching, it was possible to obtain mechanical characteristics in steel castings comparable to those of forged steels, and he made cast (not wrought) projectiles and gun tubes which successfully passed the acceptance tests.

Third, he converted phosphoric cast iron into steel in a furnace lined with chromite brick.

He skimmed the slag before the final additions, and therefore made the first steel castings on a basic hearth at the Terrenoire Works in 1880. Consequently he is the real inventor of dephosphorization on the basic hearth, by transferring the essential principle of the Thomas basic converter to the open-hearth furnace.

Furthermore, refractory linings on mold tops were employed at Terrenoire Works for the first time, so as to localize the segregation into the top of the ingot from where it can be cropped.

For these and many other reasons, the British Iron and Steel Institute bestowed upon him the Bessemer Medal and appointed him French honorary vice-president; likewise he was made an honorary member of the American Institute of Mining and Metallurgical Engineers. In spite of all this, there are doubtless many metallurgists, chiefly among the younger generation, who are ignorant of his name and would be at a loss to quote his fundamental discoveries.

ALBERT PORTEVIN

Concentrating Low Grade Iron Ore by Fire

SCHWEINFURT, GERMANY — A significant statement is made by R. S. Archer in his review of the iron and steel industry, printed in METAL PROGRESS for January. He writes, "There is in view no basically new process of steel manufacture, applicable in our principal industrial areas, which offers any substantial economies in the making of steel." While this is doubtless a reasoned statement for conditions existing in America, with your wealth of ores and fuels, it foreshadows great economic difficulties to areas like the Germany of today, whose economic life and territory have been dislocated to such an extent that desirable raw materials are no longer freely available. Hence the extraordinary interest taken in the successful experiments conducted at the Krupp works in Magdeburg-Buckau and described a few months ago by Friedrich Johannsen before the blast furnace division of the German Iron and Steel Institute (V.d.E.). At that time this direct-reduction or concentration process had been tested in furnaces of 3-ton and 10-ton daily capacity. It is estimated that 300 tons could be put through a furnace 12 ft. in diameter and 160 ft. long (cement kiln type).

Low grade brown ores from the Salzgitter mountains are being treated, analyzing from 26 to 50% iron. It and the necessary fuel are crushed to 3/8-in. size and mixed with flue dust and fine metal nodules (derived as noted below) and charged into the end of the kiln. As it proceeds through the furnace, three actions occur:

The mixture is first dried and preheated by cross-current gases in the preheating zone, where it is brought to about 1100° F. This uses about 20% of the total furnace length, and introduces the ore into the reduction zone, wherein carbon in the mix reacts with the iron oxides in the charge, which remains granular until the temperature reaches 2000° F. The CO gas formed in the charge in this reduction zone can burn within the mass only so long as any free oxygen comes from the lumps. Such gas (CO), continuously generated, forms a protective layer over the charge, which keeps the oxidizing gases in the rest of the furnace away from the charge. The heat required for reduction is led through the hot shell of the furnace, turning within an oven built about this section of the furnace.

Slag begins to sinter at about 2000° F. and the temperature is raised (by means of a flame blowing into the lower end of the furnace) to about 2300° F. This sintering zone has a refractory lining, and occupies about 20% of the length. In this the heating gases oxidize part of the reduced spongy iron to ferrous oxide, which forms a slag with the siliceous gangue; the heat of combustion of the iron plus the heat of slag formation raises temperatures momentarily to as high as 2550° F. During this process the pasty slag separates from the skeleton of sponge iron particles, and the iron welds onto larger, slag-free lumps of

Microstructure, at 250 Diameters, of a Porous, ¾-In. Nodule of Iron Alloy Produced by Direct Reduction

iron; the latter grow as they roll over and over in the plastic slag. Oxide, remaining within the lumps, is reduced in this final zone; however, so little CO is formed that the protective layer of reducing gas no longer forms over the charge as it did in the reduction zone. The alternating oxidation and reduction through the whole final zone produces practically slag-free lumps of iron, together with a slag, low in iron.

The material discharged consists of metallic lumps ranging from the finest size to about 7 in. diameter, embedded in pasty slag. It is quenched in water, crushed to 25 mesh, and screened. The iron lumps remain the same size, but everything through 25 mesh is small lumps of metal, sponge iron, and slag. Magnetic separation of the fines yields a slag to waste (containing 1 to 5% ferrous oxide plus 0.2 to 0.6% metallic iron) and a magnetic concentrate with 55 to 75% total iron, which is 5 to 15% of the ore charged, by volume.

This magnetic concentrate is put back into the furnace and forms crystallization nuclei for new lumps. Flue dust is caught in a chamber or dust catcher, and also added to the furnace mixture.

Semi-commercial operations yield a granular or lumpy form of iron 60 to 80% of which is in lumps over ⅜ in. diameter. It is somewhat porous and is very good material for subsequent melting without dusting or undue oxidation. Structure (page 59) consists of pearlite granules surrounded with thick ferrite sheaths, the latter containing considerable phosphide eutectic. The black regions are cavities. Little or no slag is retained. Chemical analysis ranges from 0.5 to 1.5% carbon. Much sulphur is picked up from the sulphur in the fuel, and over 75% of the phosphorus in the ore goes into the lumps or nodules; only one-quarter or less of the manganese is reduced at the low temperatures prevailing.

The recovery amounts to 90 to 96% of the iron in the ore, an extraordinary result on low grade ores. If they were concentrated by ore dressing methods only 70% of the iron could be recovered; likewise in former experiments with direct reduction the best yields on low grade ores were about 60%. When concentrated ores are smelted in the blast furnace, extra limestone and fuel must be added to the burden to slag the siliceous gangue, and therefore the cost of iron made from concentrate is about 57.5 marks. It would appear that the best method of handling the nodules (and reducing the sulphur content) would be to add them to the burden of a blast furnace operating on higher grade ore; cost of iron so made is estimated to be about 38.5 marks. Present cost of pig iron using good foreign ore is about 45 marks per ton.

In experimental operation, fuels of various grades have been successfully utilized, such as coke dust, low temperature coke, lignite, anthracite dust, and slack coal. From 525 to 650 lb. of coke dust is required to reduce a ton of dry ore containing 40% iron. About 10% of this is burned at the delivery end to generate heat for the sintering zone. Slope and rotation of the furnace is such that the material takes about 6 hr. to work its way through.

It would seem that these large scale experiments hold high promise for the conversion of low grade ore into a high grade raw material for the blast furnace. It is a concentration by fire, using the low grade fuel available within our borders, and appears to yield, economically, a much better yield of iron than the other processes.

Under any circumstance, it is a new approach to the problem of direct reduction, which, as described in my letter last June, heretofore has usually aimed at a metal of much higher purity, suitable for direct melting into steel in a conventional furnace.

HANS DIERGARTEN

Hans Diergarten, Ph. D.

Inspiration and encouragement to specialize in metallurgy came to Dr. Diergarten from the late Dr. Oberhoffer, director of the Institute of Ferrous Metallurgy in Aachen. In conjunction with Messrs. Tiwowarsky and Eilender he studied the analysis of iron and steel for oxygen and nitrogen, and the effect of gases on metal. Since 1929 he has been chief of the research laboratory of the German subsidiary of S. K.F., manufacturers of high grade ball bearings.

Superheat Destroys Crystal Nuclei

LEOBEN, AUSTRIA — Many publications have considered the coarse crystalline structure of ingots, and several attempts have been made to formulate the general laws of solidification. Tammann has pointed out that the average crystal size is the combined result of the degree of undercooling at the moment when solidification begins (which increases rapidly as the melt is undercooled) and the velocity with which the crystals grow (which increases rapidly, but then remains constant as the metal cools).

Such general rules, however, do not indicate why a columnar structure should ever occur in commercially pure metal, and this is doubtless due to the directional flow of heat and the rate of cooling, and perhaps to the fact that a crystal will grow at different rates along its principal axes (at least in certain undercooled regions). Likewise a number of questions remain unanswered concerning the persistence of nuclei in superheated melts. It was to find an answer to one or two of these that a considerable investigation was made under the direction of Professor Mitsche of the metallurgical department, University of Leoben, and a summary of the results is given below.

Superheating Reduces Nuclei

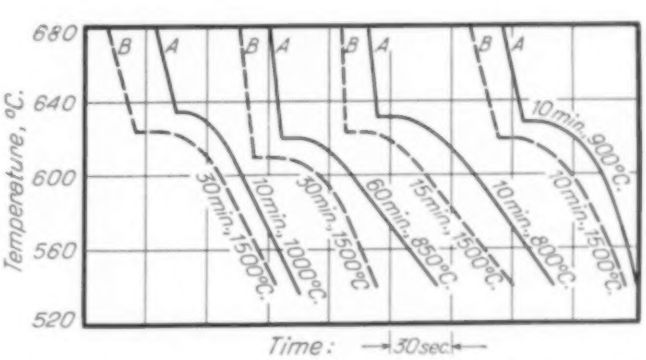
Metal	Melting Point	Temperature of Melt	Crystals per Unit Area
Al	660°C.	700°C.	110
		1300	62
		1900	45
Sb	630	800	100
		1350	12
Cu	1083	1100	72
		1700	55

It is agreed that the final ingot structure is greatly influenced by the number of nuclei present when crystallization starts. These nuclei come from two sources; first are intrinsic nuclei, the remnants of crystals — those small masses where the atoms retain the crystalline lattice — which remain in the liquid; and second, solid foreign bodies, metallic or non-metallic particles. Illustrations of the latter effect abound in practice and in the literature, and in all our work the greatest care was taken to keep the factor of impurities constant when studying intrinsic nuclei.

Many observed facts are explained by the supposition that any metal, even if melted at a *very* slow rate, contains many "lattice remainders" when fully molten, and that these disappear gradually, depending on the temperature and time of superheat. This relationship is clearly shown in the adjoining table, which lists the number of crystals counted in the macrostructure of a series of small ingots, cast from identical metal after various degrees of superheat.

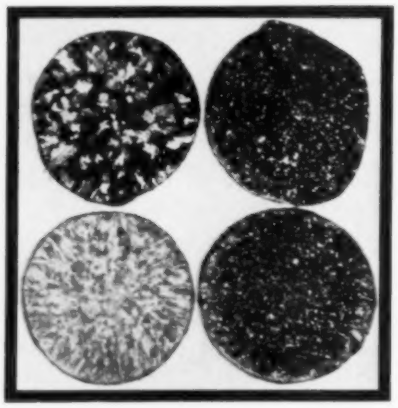
Single crystals may therefore be produced, in a simple manner, in pure metal (which has few foreign nuclei) by long, high superheat to destroy the intrinsic nuclei, followed by very slow rate of cooling, which prevents the spontaneous formation of nuclei in undercooled metal. Single crystals of electrolytic copper were prepared in this way by us, in size up to 1 in. diameter by 2 in. long, proven to be such by their X-ray diffraction patterns. The other metals (aluminum, silver, antimony, and zinc) were not as pure, and the largest crystal produced was much smaller.

It may be deduced that the amount which a melt may be undercooled before solidification will depend, among other things, upon the number of intrinsic nuclei present. Available data as to this are conflicting, although cross-sectioned ingots cast under various controlled conditions showed grain sizes which conformed to that supposition. We depended rather on cooling curves, such as those shown in the diagram for commercial aluminum. To secure these the molten metal was poured into narrow, deep molds, through opposite sides of which had been introduced the bare ends of fine thermocouple wires. The molten metal, therefore, formed the junction. Various degrees and times of superheat were tried, as well as various cooling rates. Casts were made from split heats, to avoid differences in chemical composition and nonmetallic inclusions. One series of tests on chemically pure aluminum, cast in chamotte molds, is



Cooling Curves of Commercially Pure Aluminum; Split Heats Poured Into Chamotte Molds, Cold or Preheated. "A" of each pair was held only a little above the melting point; "B" had been superheated as noted and furnace cooled to the pouring temperature of the first portion

Macrostructure of Small Ingots of Split Heat of Commercially Pure Aluminum. Upper pair cast in chamotte molds; lower pair cast in iron molds. Metal at left had been held at 700° C. for 15 min.; metal at right had been held at 700° C. for 15 min., heated to 1300° C. and held 15 min., furnace cooled to 700° C. and cast



given in the diagram, wherein the undercooling of 8 to 10° C. is figured as the difference of observed solidification temperatures of the corresponding pair, rather than the distance below 660° C., the melting (solidification) point of aluminum under ideal conditions. Influence of the degree of superheat (number of nuclei) and the rate of cooling (chamotte vs. iron molds) is indicated in the adjoining macrographs.

Our experimental results are consistent with the following generalizations:

1. Superheating a molten metal diminishes the number of intrinsic nuclei of crystallization, and increases the capacity for supercooling before solidification commences.

2. The relative influence of these two factors on the average grain size in the ingot depends upon external conditions governing the rate of cooling, according to the laws set forth by Tammann and quoted at the outset.

H. Pessl

Notes on Aluminum Alloys Exposed to Sea Water

TURIN, ITALY — Notwithstanding the great progress made in the last few years in the manufacture of aluminum alloys to resist corrosion in sea water and marine atmospheres, their applications in European naval construction are not so extensive as they should be, when the great advantages of their low specific gravity are taken into account. Extensive use of aluminum and thin stainless steel for deck structures on American warships is proof of the fact that your naval constructors are well informed on these matters.

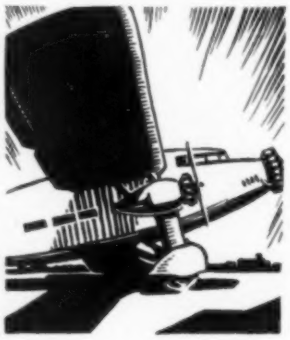
This fact may be partly due to the inadequate attention paid to the special conditions of service. In this connection a surprising example is derived from Dr. Panseri's examination of some aluminum ingots recovered from the cargo of a boat torpedoed in 1918 in the Mediterranean. They had the following average composition: Aluminum 98.6%, silicon 0.8%, iron 0.4%, and copper 0.2%.

In spite of the low purity of the metal, the corrosion of the ingots was very slight and strictly superficial, and the tensile strength perfectly normal. It is evident that in this case the seemingly extraordinary resistance of the metal to the action of sea water was mainly due to the special conditions of exposure, especially to the small quantity of oxygen dissolved in sea water at a depth of approximately 250 ft.

Strong aluminum alloys coated with pure aluminum (the well-known "alclad") are rightfully regarded as having excellent resistance, especially when given the anodic surface treatment. Users generally understand that the heating of such coated alloys should be avoided, but comparatively few data are available about the change in chemical resistance and physical properties due to heat treatments of considerable duration. C. Guidi has recently published extensive researches in this direction.

Brief heating at or below 900° F. improved the alclad sheet; 5 min. at or above 950° F., however, caused very erratic performance, explainable only by great alterations in the structure of the metal. Examination led to the indication that this was primarily due to diffusion of copper from the alloy into the pure surface layers, to the detriment of the quality of both core and skin.

By far the greatest interest of naval and aircraft constructors has been in aluminum alloy castings of one fundamental type, containing aluminum, silicon, magnesium, manganese, antimony, and sometimes small percentages of iron and titanium. The discovery of these alloys is ascribed to R. Sterner-Rainer of the Karl Schmidt Co. of Nekarsulm, Germany. The initials of the company name give the code "K.S.S." for Karl Schmidt's Seewasser, generally adopted for these alloys in all European countries, except France, where it has been replaced by the word "Thalassal."



The composition for alloys of this variety adopted in Italy is in-

(Continued on page 78)

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NOTES ON 29-9

(Cont. from page 51) to impact at room and elevated temperature for all applications of high temperature service for which the material is suitable.

Its useful strength at high temperatures closely approximates that of another important alloy used for furnace parts which reverses the importance of the alloys and contains approximately 35% nickel and 15% chromium. Curves on page 50 show that the high temperature characteristics and design values of 28% chromium, 10% nickel alloy are but slightly lower than the 35% nickel, 15% chromium alloy. Those design strength curves have been based on several years' observation of high temperature structures, rather than on laboratory tests; due allowance has been made for a possible overheating or overloading in service, and for the reduction of effective cross-section due to oxidation and corrosion. They can therefore be used by designers with a good deal of assurance.

A word of explanation as to these curves may be in order: The short time tensile strength are laboratory test values and refer to breaking loads without any prior deformation. The working stress is to be read against the appropriate extended scale at the left of the diagram, and gives design values for long time service. Sections so proportioned will be dependable for upwards of 10,000 hr., with negligible yield, creep, or permanent deformation. The "design factor" is merely the ratio between short time tensile test and the recommended design or working stress, and should not be regarded as a factor of safety, since the service life of alloys is usually limited by creep or time-yield, which bears no relation to short time tensile test.

Heat resisting types of this alloy have found particular utility in the construction of furnaces in which it is desired to maintain reducing atmospheres in the presence of products of combustion high in sulphur. It takes the form of conveyor chain, beams, rails, trays, tubes, shafts and rollers. The alloy is exceptionally well adapted also to resist oxidation at very high temperatures.

For carburizing boxes and containers it is not as satisfactory as the high nickel alloys, being more subject to carburization and subsequent embrittlement.

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(signed) AMERICAN SOCIETY FOR METALS.
Ray T. Bayless, *Assistant Secretary*

Subscribed to and sworn before me on this 29th day of April, 1935.
(seal) Arthur T. Wehrle *(Notary)*

GRINDING CRACKS

(Continued from p. 53) the tool in question from 15 to 30 min. in a solution of equal parts hydrochloric acid and water. Lest it be supposed that "hydrogen embrittlement" is the cause, the same result can be had by pickling in nitric acid solution, an acid whose reaction does not release atomic hydrogen.

Quenching cracks have characteristic arrangement in that they dispose themselves about changes in section, re-entrant angles, or corners, and are relatively few in number. Grinding cracks, on the other hand, usually comprise a system of cracks, more or less parallel to each other, and placed at right angles to the direction of grinding. Frequently so many short cross cracks appear that the surface has a mosaic structure.

It should not be inferred, either, that the heat treater never spoils work by incorrect hardening. Unfortunately, this sometimes happens even under best supervision, and in the hands of the most conscientious and reliable workman. Such damage will become evident, however, long before the part reaches the finish grind. The writer has yet to see a hardened part, promptly reheated and held for a generous period of time in the tempering furnace, that would develop grinding cracks, unless the finish grinding was carelessly or improperly done.

During the process of grinding, noticeable surface discoloration is a warning. It indicates faulty grinding. The cause is usually the generation of excessive heat upon the surface of the part being ground from the friction of a glazed grinding wheel, or heavy feeds. Generation of such excessive heat upon the surface of a hardened tool causes this surface to expand, which in turn sets up stresses that cause the surface to crack either in the sudden overheating or subsequent cooling.

For finish grinding it is advisable to use a soft wheel and light cuts together with rapid passes over the work and generous flow of cooling solutions at the point of contact. Finally it is money well spent to return the part to the heat treat for a final stress relief, at say 300° F., just before the finishing touches by light grinding. This is especially desirable in tools of highest precision, which must hold their shape to close tolerances while in use.

HELPFUL LITERATURE

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Batch Carburizing

Actual operating data on clutch parts and bearing races and cones are given in Surface Combustion's folder on gas carburizing in horizontal batch type units using the Eutectrol process. Bulletin Myx-51.

Centrifugal Compressors

B. F. Sturtevant Co. has a line of centrifugal compressors designed particularly for industrial furnace applications. These are illustrated and described in Bulletin Myx-58.

Low-Cost Controller

Leeds & Northrup has a new low-cost Micromax controller for use where simple "on-off" control is adequate without indication or record, and where first cost must be low. Described in Bulletin Myx-46.

Multi-Color Records

A handsome booklet describing Foxboro's multi-color potentiometer recorder for 2, 3, 4, or 6 temperatures reproduces charts in actual color. Specifications for one model are given. Bulletin Myx-21.

Tacks and Nails

Cut tacks and small cut nails (Grand Crossing Quality) of all types and for all uses are catalogued in Republic Steel Corp.'s latest booklet. An index is provided for handy reference. Bulletin Myx-8.

Welding Electrodes

Electrodes for welding alloy steel, particularly "Cor-ten" steel, used for railroad cars and outdoor structures, are described in Metal & Thermit's new booklet. Bulletin Myx-64.

Misco Alloys

Compositions, properties, and applications of Misco stainless, heat, and corrosion resisting castings are given in an illustrated folder offered by a pioneer producer, Michigan Steel Castings Co. Bulletin Mx-84.

Welding Design

Valuable technical information on the design of such parts as wheels, levers, bosses, and machinery bases for arc welded steel construction is contained in a series of "Application Sheets" issued by Lincoln Electric Co. Bulletin Myx-10.

Sheffield Steels

Wm. Jessop & Sons, Inc., have a leaflet which tells why a special anneal and a proper balancing of carbon, manganese and tungsten combine to make Sheffield Superior oil hardening steel non-distorting and easily machinable. Bulletin Jn-61.

Non-Ferrous Annealing

General Electric Co. describes bell-type furnaces for annealing non-ferrous metals in a new folder which gives many data on operation and performance. Description is from technical rather than sales angles. Bulletin Ar-60.

Oxwelding Stainless

Linde Air Products Co. has published a handbook of instructions for successfully welding corrosion resisting steels by the oxy-acetylene process. Welding procedures and weld treatments are carefully explained. Bulletin Jy-63.

Rockwell Tester

The Rockwell Superficial Hardness Tester is applicable to far thinner sheet and strip than the regular Rockwell. Its use for nitrided and case hardened parts is also described by Wilson Mechanical Instrument Co. in Bulletin Myx-22.

Beryllium-Copper

Beryllium-Copper, produced by American Brass Co., can be heat treated to tensiles as high as 181,000 lb. per sq.in. It comes in sheets, wire, rods, tubes and forgings. A fine booklet tells how to fabricate and heat treat. Bulletin No-89.

Aluminum Alloys

Working facts on aluminum — the properties and heat treatment of both cast and wrought alloys — are briefed for the manufacturer and designer in a booklet by Aluminum Co. of America. An appendix gives tables of physical properties, forms and sizes available. Bulletin Dc-54.

Free Cutting Steel

Jones & Laughlin Steel Corp. has published in attractive booklet form a record of 15 years of research by their metallurgical department into the machinability of free cutting steels. Bulletin Ob-50.

High Strength Steel

Cromansil steel, a development of Electro Metallurgical Co., has high strength and good ductility "as rolled" and is thus fine for structural applications where its great strength saves much dead weight. Bulletin Je-16.

Carbonol Process

The Carbonol process of carburizing is described in detail in a folder of Hevi Duty Electric Co. Results are said to be quicker, cleaner and better cases at very low cost. Bulletin Jy-44.

Alloy Castings

Compositions, properties, and uses of the high nickel-chromium castings made by The Electro Alloys Co. for heat, corrosion and abrasion resistance are concisely stated in a handy illustrated booklet. Bulletin Fx-32.

Pyrometer Accuracy

A thought-provoking folder of Hoskins Mfg. Company explains how the use of Chromel-Alumel for pyrometer lead-wires makes it possible to take full advantage of modern pyrometric instruments. Bulletin Ob-24.

Hardening Furnaces

The C. I. Hayes Certain Curtain electric furnace for the range 1200 to 1850° F. is described in this bulletin. Its applications to hardening of carbon, stainless, and alloy tool steels and to preheating high speed steel are discussed. Nv-15.

Bright Annealing

Electric Furnace Co. tells about their controlled atmosphere furnaces for continuous deoxidize annealing, bright normalizing and annealing ferrous and non-ferrous metals. Work comes clean, bright and dry from these furnaces. Bulletin No-30.

Recuperators

Results obtained with Carborundum Company's recuperators using Carbofrax tubes are fuel savings, closer temperature control, faster heating, and improved furnace atmosphere. Complete engineering data regarding application to various types of furnaces are given in Bulletin Fx-57.

Carburizing Boxes

Driver-Harris Co. devotes a folder to Nichrome cast carburizing boxes. Physical properties at room temperature and under operating conditions are given, as are the advantages of Nichrome castings for such service. Bulletin Jr-19.

Tubing Weight Tables

Timken Steel & Tube Co. has issued a series of "Master Weight Tables" for round steel tubing, on letter size heavy paper, punched for binding. Weights per lineal foot of length are given for all sizes of hot finished and cold drawn tubing. Bulletin Mx-71.

Heat Treating Machine

A new continuous machine for atmosphere heat treating is covered by an American Gas Furnace Co. bulletin. A variety of treatments may be performed by passing different atmospheres through the muffle. Description is complete and interesting. Bulletin Jr-11.

Heat Treating Manual

A folder of Chicago Flexible Shaft Co. contains conveniently arranged information on heat treating equipment for schools, laboratories and shops, and also illustrates the several types of Stewart industrial furnaces. Bulletin Ar-49.

Dark Room Layout

A novel card 9½x13 in. containing suggested arrangements for a photomicrographic dark room has been designed by Bausch & Lomb. Costs for installation are estimated, and on the reverse side are printed rules for using the dark room. Bulletin Jx-35.

Moly Matrix

Climax Molybdenum Co.'s little monthly newspaper contains many interesting and informative articles. Get the latest issue by asking for Bulletin Ax-4.

Testing with Monotron

Shore Instrument & Mfg. Co. offers a new bulletin on Monotron hardness testing machines which function quickly and accurately under all conditions of practice. Bulletin Je-33.

Turbo-Compressors

The new items in Spencer Turbine Co's bulletin are a new and smaller "Midget" turbo for individual mounting, a single-stage line which effects new economies, and the gas-tight turbos for acid and explosive gases. Bulletin Mx-70.

Cast Vanadium Steel

Jerome Strauss and George L. Norris have written a technical booklet for Vanadium Corp. of America describing the properties developed by steel castings containing various percentages of vanadium. Bulletin S-27.

Radium Radiography

Advantages of portability, ease of application and manipulation in examination of castings, forgings, molds, weldings, and assemblies are attributed to radium for industrial radiography. Details are given in a booklet issued by Radon Co. Bulletin Jx-56.

Steels for Automobiles

The story of "Cold Finished Steel and the Automobile" is very interestingly told by Union Drawn Steel Co. Improvements in automotive design are reflected in improvements in cold drawn steels, the advantages of which are now available to many other industries. Bulletin Ax-83.

Liquid Carburizing

E. F. Houghton's Perliton liquid carburizer is the subject of a 23-page booklet. Depth of case, speed of penetration, and other results are well illustrated with graphs and photomicrographs. Nv-38.

Controlled Steels

Carnegie Steel Co. has published a very interesting booklet which describes in some detail the process control used in the production of uniform steels. Bulletin Je-85.

Big-End-Up

Gathmann Engineering Co. briefly explains the advantages of steel cast in big-end-up ingots, showing the freedom from pipe, excessive segregation and axial porosity. An 82% ingot-to-bloom yield of sound steel is usual. Bulletin Fe-13.

Photocell Pyrometers

Recording potientiometers using a beam of light, a mirror galvanometer, and a photo-electric cell give instantaneous control with high sensitivity and accuracy. The different varieties made by C. J. Taglibue Mfg. Co. are described in a 16-page letter-size booklet. Bulletin Fx-62.

Neophot

"Neophot" is the name of a new metallograph of radically new design and universal adaptability. A pamphlet distributed by Carl Zeiss, Inc., gives its applications and features and is well illustrated with beautiful samples of micrographic work. Bulletin Jx-28.

Blast Cleaning

A centrifugal machine which cleans castings without the use of compressed air is the subject of Pangborn Corporation's new folder. How and why 1800 lb. of castings can be cleaned in 8 min. at low cost is told. Bulletin Jx-68.

Manual of Pyrometry

Brown Instrument Co. offers an elaborate manual which describes the 50 exclusive features of their potentiometer pyrometer. The book will greatly interest those who must maintain accurate temperature. Bulletin Jr-3.

Tempering Furnace

Technical details and operating data on Lindberg Steel Treating Co.'s new Cyclone electric tempering furnace, which has shown a remarkable performance record in steel treating operations, are given in Bulletin Fx-66.

Metallograph

A new 36-page booklet of E. Leitz, Inc., contains all information on the Leitz large Micro-Metallograph, MM 1. Excellent photomicrographs are reproduced to show its capacity. Special attention is given to the darkfield illumination feature. Bulletin Se-47.

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in Bulletin D-17.

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WHAT TO READ

Heat Treating and Finishing

Hardening Cam and Axle Shafts in Controlled Atmosphere, A. H. Allen, Steel, April 15, p. 38 . . . . Carburizing of Copper Steels, S. Epstein, Metals & Alloys, April, p. 91.

Methods of Testing Thermocouples, Wm. F. Roeser, Bureau of Standards Research Paper 768 . . . . Standard Tables for Chromel-Alumel Thermocouples, W. F. Roeser, Bureau of Standards Research Paper 767.

Rubber-Faced Rollers for Continuous Pickling Tanks, W. E. Genung, Steel, April 15, p. 49 . . . . Tumbling and Burnishing, H. R. Simonds, Iron Age, March 28, p. 25.

Properties and Tests

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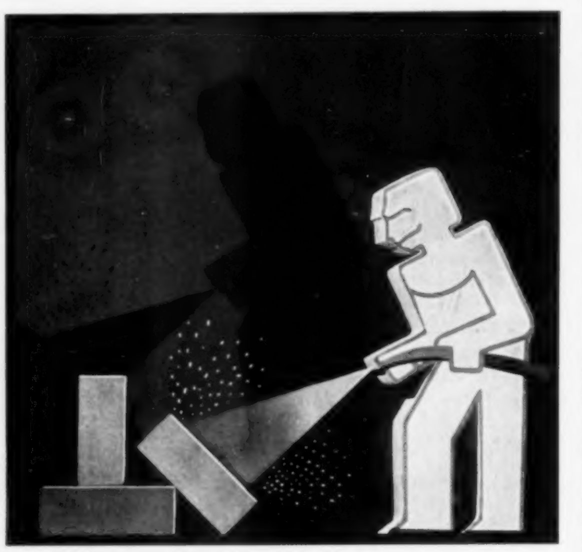

CORRESPONDENCE

cluded in the following chemical limits for the principal elements:

Magnesium	from 1.8 to 2.2%
Manganese	from 1.2 to 1.4%
Antimony	from 0.15 to 0.25%
Silicon	from 0.5 to 0.7%
Iron plus Titanium	from 0.15 to 0.3%
Aluminum	balance

The principal physical properties are:

Tensile strength (sand cast)	24,000 to 31,000 psi.
Specific gravity	2.71 to 2.73 grams per cu. cm.
Melting point (liquidus)	1185° F.
Pouring temperature	1300 to 1400° F.
Interval of solidification	1185 to 1150° F.
Shrinkage (linear)	1.3 to 1.5%
Coefficient of thermal expansion (between 20 and 100° C.)	0.000023
Thermal conductivity	0.346 c.g.s. units
Electrical conductivity	34 to 41% of copper standard

As for the corrosion resistance, its loss of weight per 100 sq.cm. surface in active NaCl solution varies between 0.1 and 0.2 grams in 24 hr.

One of the typical advantages of this alloy for naval construction is that (contrary to what should be expected from the electrolytic corrosion theory) it withstands the corrosive action of sea water when in contact with bronze, brass, and stainless steel. A typical use is for port covers on Italian warships; although these are riveted directly on steel plates and their fittings are of bronze, there is no sign of corrosion.

Some manufacturers — considering that the antimony has no practical effect on the corrosion resistance of K.S.S. — have developed other alloys of similar composition without antimony. The more generally used of these alloys in Italy is the "anticorodal special 198," in which the silicon content is limited to 0.3%. Its resistance to the action of sea water is practically the same as K.S.S. from Germany.

FEDERICO GIOLITTI